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CIVILIZATION AND SCIENCE.[1]

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PART I.

I.—The Primordial Period, or Age of Unconscious Inferences.

THE relation of man to Nature primordially and of savage races in the present day is, as we know, very different from what it has been represented to be by poets and philosophers. In the delightful pictures their fancy painted there was nothing true: the idyllic conditions amid which they fancied the still youthful human race as living never have existed anywhere. The history of man the world over has its beginning not in a golden age, but in an age of stone. Instead of noble shepherds and lovely shepherdesses, who, under benignant skies amid picturesque scenes, live in innocence on the produce of their flocks, decorously enjoying all the purest gifts of fortune, the reality presents to our view rude, uncouth hordes struggling against hunger, against wild beasts, against the inclemency of the seasons; buried in filth, in groveling ignorance, and brutal selfishness; their women made slaves, their old people cast out; practising cannibalism first out of necessity, and then because superstitious usage had hallowed the custom.

Into the mental state of such beings we can enter as little as into that of children. We cannot strip ourselves of the acquisitions made by the generations whose successors we are, and whose priceless hoardings of the fruits of their labor now inure to our benefit. If, as Paul Broca teaches, the mean cerebral mass of Parisians in the present day exceeds that of Parisians in the twelfth century, may we not assume

[1] An address delivered before the Scientific Lectures Association of Cologne. Translated from the German by J. Fitzgerald, A. M., and carefully revised by the author.

our brain to have, by a process of gradual improvement, become more highly developed than the brain of the men of the stone age, 100,000 years ago? And this brain, more perfect as it is by nature, has been, at an early period of its life, subjected to innumerable unconscious influences, and, later, to the conscious influences of education, which render it in some sense incommensurable with the brain of those as yet half-brute creatures.

The instinct of causality, the questioning about the "why" of things, which we greet in our children as a precious token of their awakening human intelligence, is by some philosophers regarded as an original characteristic of man's mind. Others hold even this to be a derived faculty—that it results from the faculty of generalization. So much is certain, that, among men in a low grade of culture, the instinct of causality is satisfied with reasons for things that hardly deserve the name of *reasons*. Nothing, we are told by Charles Martins, strikes one so forcibly in conversing with the inhabitants of the Sahara as their lack of development in this respect. These people have no idea of "cause" or of "law" as we understand those terms. For them it is the *natural*, and not the *supernatural*, that has no existence. The French officer of engineers who sinks through the gypsum crust of the desert an artesian well, thus procuring for them the blessing of a new date-grove, is, in their eyes, not a man of superior acquirement whose eye penetrates to the interior of the earth, and who knows how to discover what there is hid, but a miracle-worker, who, albeit an infidel, is on better terms with Allah than themselves, and who, like Moses of old, strikes water from the rock.

In that stage of human progress science does not as yet exist. It is the childhood period of our race, and as such it has many points of resemblance to the childhood of the individual man. As this is *par excellence* the period of unconscious inferences, so it is to be admitted that such inferences, guided by experiment, have led to the invention of the first tools. These were invented, not by one man, nor at one spot upon the earth, but by many, and at points very distant from one another. Thus originated levers, rollers, wedges, and axes; clubs and spears; slings, *sarbacands*, lassos; bows and arrows; oars, sails, and rudders; fishing nets, lines, and hooks; finally, the use of fire, by which, as by speech, man is best distinguished from animals, and which even anatomically stamps him with the character of a soot-stained lung. Man, therefore, at an early period was unquestionably entitled to the epithet bestowed upon him by Benjamin Franklin of "the tool-making animal."

II.—The Anthropomorphic Age.

Now, whatever confronted him in the shape of a compelling power of Nature, being either beyond or adverse to his own will, and whether the same affected him favorably or unfavorably, in it, owing to a propensity deeply rooted in the human mind, he recognized the act of

beings like himself, though usually hidden to his senses, whom he fancied to be free from the limitations to which he himself was subject, but who for the rest had the same emotions of love and hate, gratitude and revenge, with himself. The sum of such imaginings of a given nation at a given time we call its religion; but it might also be regarded as the personificative or *anthropomorphic* stage of our system of Nature. This attitude of man toward Nature is very clearly seen in Homer.

According to David Friedrich Strauss,[1] the bias of man's mind toward the personification of the forces of Nature has its root in the fact that so he hopes to win the favor of those unknown and dreaded powers. Perhaps a profounder reason could be assigned. Man originally knows no other cause of occurrences save his own will, the exercise of which is matter of direct experience, and hence it is that he refers all events back to the action of a will like his own. This explanation appears all the more probable, inasmuch as the same conception, only in a more refined form, still unconsciously pervades our theories of natural science. For undoubtedly this is the origin of the idea of Force which has done so much mischief in science, and which, despite all that we can do, is still ever creeping in.[2] We even see certain addle-brains in dead earnest entertaining the fantastic conceit that, by the aid of such anthropomorphic ideas as these, the mutual attractions of bodies across empty space can be explained. What difference is there between that Will which, according to our latest Nature-philosophers, drives the atoms together, and the gods of antiquity who animated the planets? The serpent of human knowledge has once more bitten its own tail; human science has reverted to its starting-point.

Very conclusively, as would appear at first sight, Buckle, in his "History of Civilization,"[3] from the aspects of Nature in different regions, deduces the religions there originating. He shows us India bounded on the north by the Himalayas, where Mount Everest towers to a height twice as great as that of Mont Blanc, where the Pass of Kwen-Lun leads into Thibet at an elevation equal to that of Caucasus, and where the Eiger, the Mönch, and the Jungfrau, piled on top of one another, would only fill up one of the lateral valleys. Toward the south he shows us the Indian Peninsula, with its harborless coasts, projecting into a sea that stretches uninterrupted to the pole, and which is often swept by cyclones. From the mountains to the sea streams not to be bridged over flow, passing through interminable jungles, in which wild beasts and venomous serpents threaten the life of the wayfarer at every step. According to the official returns, about 11,000 persons lose their lives annually in British India from the bites of serpents, especially the cobra de capello.[4] Failure of crops, famine, and

[1] "The Old Faith and the New," New York, 1875.

[2] *See* Du Bois-Reymond's "Untersuchungen über thierische Elektricität," Berlin, 1848, vol. i., p. xlii.

[3] "History of Civilization," New York, 1878, vol. i., chapter ii.

[4] Fayrer's "Thanatophidia of India," London, 1872, p. 32. Most probably, the num-

inundations, succeed one another with lamentable regularity in Bengal. The cholera-plague has its home in the delta of the Ganges; and in the devastating Indian pestilence of Rajastan, characterized by gangrene of the lungs, Hirsch recognizes the black death of the middle ages, the Florentine pestilence described by Boccaccio, which, like cholera in our times, held its ghastly circuit through the world.

In the face of such aspects of Nature as these, asks Buckle, which are ever menacing him with annihilation, must not man feel himself small and powerless? He arrives at no conscious, reasoned conclusion, but stolidly fancies to himself certain dominant and unfriendly powers as the authors of these dire calamities. He deifies the objects of his fears, erects altars to them, and offers to them sacrifice.[1] Hence it is that Hindoo mythology teems with monstrosities. Men there live 100,000 years. The ages of the world are reckoned by units followed by sixty-three zeros. The god Siva, who constitutes with Brahma and Vishnu the Indian trinity, is a monster with three eyes, wearing a necklace of human bones and a girdle of serpents. In one hand he holds a skull; a tiger's skin is his mantle; and over his left shoulder the deadly cobra rears its head. His wife Doorga is represented as of a blue complexion, with gory hands, lolling tongue, four arms, a giant's skull in one hand, a necklace of human heads; round her waist are the hands of her victims. All Hindoo deities are in like manner characterized by some inhuman or monstrous aspect—for instance, an excess of limbs or an unnatural complexion.

Buckle thinks he finds in Central America evidences of a like influence npon man's religious ideas of the dangers of life in tropical regions. The traveler Kennan refers the Shamanism of the inhabitants of the Siberian steppe to the dismal aspects of Nature by which they are surrounded. Alone on the *toondra* with his herd of reindeer, watching in the glare of the northern lights the howling wolves round about, the Korak stands on guard through the polar night, and fancies himself to be beleaguered by evil spirits, whose wrath he seeks to conjure away by offering to them his dogs, or by the practice of magic arts.[2] It needs not to be told how fully the gloomy sublimity of the Eddas accords in the same sense with the aspects of Nature in Iceland, where volcanic forces are ever striving with ice for the upper hand.

As contrasting with these aspects of Nature and the religions which owe to them their origin, Buckle points to the tamer and more pleasing scenery of Greece, and thence would infer the humanly beautiful character of the Hellenic mythology. With its multitudinous promontories, forming landlocked harbors, and itself surrounded by a number of beauteous islands, Hellas rises out of the Mediterranean, bearing

ber of victims is 20,000. (*See* also Sir James Paget *apud* Archibald Dickson, "The Vivisection Question," London, 1877, p. 38.)

[1] *See* Edmund Burke's *lumen dicendi* in the proceedings against Warren Hastings *apud* Macaulay, "Critical and Historical Essays," vol. iv.

[2] "Tent-Life in Siberia," New York, Putnams, 1870, p. 209.

not a single peak covered with everlasting snow; it has no great streams, volcanoes, or deserts, and so healthful is its climate that during 1,000 years it was visited only by one great epidemic—the plague described by Thucydides. Here, says Buckle, man did not feel himself overpowered by Nature. Here it was possible for those myths to have their rise which still delight us with their undying charm, and this because, instead of personifying the destroying forces of Nature, they rather glorify whatever is purely human. True, even Grecian mythology is haunted by many monstrous shapes, which, though an abomination to the eye of the comparative anatomist, even yet in some measure disfigure the imaginations of our artists. Yet even against the worst of these monsters man could hold his own, as Ulysses against Scylla; often he triumphs over them, as Bellerophon over the Chimæra, Theseus over the Minotaur; and, by insensible gradations, ending in the pleasing personifications of the spirits of tree, and mountain, and spring, these creatures of the artistic imagination of the Greeks at last become perfectly human figures.

It is an easy thing to carry still further these ideas of Buckle's—which have also been put forward by Lecky—and to deduce the monotheism of the Semites from their inhabiting a desert region, where Nature, in its majestic uniformity, presented itself to them lacking in color and form. It is not to be denied that in this idea of an agreement between religious forms and the aspects of Nature there is a certain degree of truth; still, like many another of Buckle's deductions, this theory bears the impress of a rather superficial rationalism. Buckle overlooks a multitude of complex intermediate facts. He makes the connection between forms of religion and the aspects of Nature far too direct. In particular, in deducing Hindoo mythology from the assumed terrifying aspects of Nature in India, he surely errs. Between the Himalayas and the Indian Ocean are thousands of square miles of fertile and now very thickly-populated country, where Nature offers nothing at all to excite the imagination in an unwonted degree. And to the originators of the Brahmanic faith what was a mountain-range which they had no occasion to cross, or an ocean which they had no occasion to navigate? Can any one suppose that, had the Jews been transplanted to the region between the Indus and the Ganges, they would have excogitated the Brahmanic, or the Koraks the Hellenic religion, had *they* migrated to the Peloponnesus? This brings us to a point on which neither Buckle nor Lecky has bestowed sufficient attention. If we were to maintain that the general psychological character of any given portion of the human race results from (among many other conditions) the local impressions under which they have developed, and that, again, from this psychological character, combined with many other circumstances, has come its form of religion, we should be stating with more correctness the causal connection between these two orders of phenomena.

III.—The Period of Speculative and Æsthetic Contemplation of Nature.

In the next place, from the nature of the country inhabited by the Hellenes, Buckle infers the symmetry of the Hellenic mind. Here, says he, for the first time the imagination was in some degree tempered and confined by the understanding, though without impairing its strength or diminishing its vitality; and, though originally the Greeks may have borrowed a good deal from the Egyptian priests, they were nevertheless the first people in history to look on Nature from anything like a scientific point of view, as distinguished from the point of view of anthropomorphism. Though still strongly tinged with anthropomorphism, this scientific contemplation of Nature had its origin in the teaching of the Ionian physical philosophers; and then, in the course of 250 years, it had attained such a height in Epicurus that in his doctrines we already find foreshadowed the law of the conservation of energy, on which the proud edifice of mathematical physics to-day rests. And though Epicurus could neither strictly formulate this law, nor illustrate it by an example, he nevertheless makes in favor of it an argument that is almost exactly the same as one made 2,000 years later by Leibnitz. Thus, then, with respect to the ultimate questions of philosophy, those ancient thinkers were, in fact, as well advanced, or rather as little advanced, as ourselves—a fact of no small importance for our theory of understanding.

When we contemplate the advances made in mathematics, astronomy, and acoustics, even by Thales and Pythagoras, it looks as though the instinct of causality had already reached maturity among the Mediterranean nations, and as though it was destined to lead men infallibly on to the latest results of scientific inquiry, as reached in our own times, and so on to domination of Nature resulting therefrom. Every one knows how different from all this the event really was.

Under the term Natural Science, we here mean not only the sum of our knowledge of Nature, organic and inorganic, its phenomena, its effects, and its laws, but also the conscious insight into the one method which aids in enlarging that sum of knowledge, and also the conscious application of this knowledge to the useful arts, to navigation, medicine, etc.—in short, the mastery and exploitation of Nature by man with a view to increasing his own power, comfort, and enjoyment.

Natural science in this sense was all unknown, we may say, to the Greeks and Romans. Those apparently so promising beginnings lacked persistent force. It is true that, during the 1,000 years which intervened between Thales and Pythagoras and the fall of the Roman Empire of the West, individual minds attained extraordinary heights. Aristotle and Archimedes must unquestionably be reckoned among the greatest teachers that have ever appeared. So, too, for some time a steady advance of science appeared to be insured by the labors of the

Alexandrine school. But nothing so plainly exhibits the hesitating step of natural science among the ancients as the simple fact that 400 years after Aristotle's day—an interval equal to that between Roger Bacon and Newton—so uncritical a collector as Pliny could exist. The case is as if Herodotus and Tacitus had exchanged places.

The history of the human mind offers few more noteworthy phenomena than this. Here are nations whose poetry and sculpture still afford us the highest delight; who, in metaphysics, history, and the science of law, produced works which, both in form and in substance, constitute the models for all ages; who to this day are our instructors in oratory, the art of war, government, and jurisprudence; but who, in their knowledge of Nature, never advanced beyond the puerile stage of credulity, and in which they rested content with the broaching of futile hypotheses. Their minds, ever ready, Icarus-like, to essay flights into the region of supersensual speculation, lacked the painstaking assiduity required to ascend the difficult path of induction—the only safe path—from particular and sharply-circumscribed facts, up to general propositions, thus rising gradually and methodically from the apparently accidental to the conception of law. True, the germ of the inductive process appears in Socrates and Aristotle; still the method which in general and theoretically was recognized as correct no one knew how to apply to particular cases; and beyond this feeble beginning nothing was done by the ancients. Even when by chance they observed aright, their very first attempt at an explanation would involve them in a tangle of such absurd and ridiculous fancies that one much prefers the theory of old Pan with his train of golden-haired nymphs ruling forest and field; of Poseidon with his trident agitating and again calming the sea; of Zeus hurling his thunderbolts. The picture drawn by Prometheus Bound of his services to humanity is a true representation of ancient science, when with astronomy, arithmetic, the alphabet, breeding of animals, navigation, mining, and medicine, he directly couples as equally important gifts the interpretation of dreams, of the flight of birds, and of the signs found in the entrails of immolated animals.[1]

In his very instructive rectorate address on "The Backwardness of the Ancients in Natural Science,"[2] Herr von Littrow deduces, from Plutarch's dialogue on "The Man in the Moon," a striking evidence of the inability of the ancients to reason scientifically. He might have quoted to the same effect Plato's "Timæus," a work abounding in intolerable absurdities; or the whole of a treatise that has come down to us bearing the name of Plutarch as its author, and entitled "Opinions of the Philosophers,"[3] of which Biot affirms that it contains the germs

[1] Προμηθεὺς δεσμώτης, v., 442, *et seq.*

[2] *See* POPULAR SCIENCE MONTHLY, vol. ix., p. 438.

[3] Περὶ τῶν ἀρεσκόντων τοῖς φιλοσόφοις. Concerning the doubtful authorship of this work, *see Monatsberichte der Berliner Akademie*, 1874, p. 485.

of all modern discoveries, nay, those discoveries themselves. Unfortunately, however, he observes, truth and error are here both equally the work of chance; the opinions here stated are like lottery-tickets, whose value is known only after the drawing.

But it is further shown by Littrow—and this is a point to which less attention had been directed—that the ancients were incapable even of *observing* scientifically.

That the eye must be trained, we know from physiology. The vast majority of mankind have no suspicion that we constantly see double images, but that we very properly disregard them. But few persons note the subsequent images remaining in the eye after having looked on an object, the opacity of the visual media, occurring even in the state of perfect health, or the hallucinations that precede sleep. It was only two hundred years ago discovered by Mariotte, that in each eye we have a blind spot, over which we throw the ground-color of the object contemplated, thus giving to this blank in the field of vision its most probable interpretation. From the year 1809, when Malus discovered the polarization of light, observers like Arago, Biot, Fresnel, and Brewster, had vainly endeavored with the naked eye to distinguish polarized from ordinary light. But since 1844, when Haidinger succeeded in doing this, the yellow tufts which bear his name belong, for every trained eye, to the normal aspect of the blue sky.

In the domain of tone-sensations, the harmonic notes, as we know, at first evade our immediate perception, though the *timbre* they give to the sound is at once noticed by every one, except those portions of the German race whose vocalization is faulty.

With such minutiæ as these, however, we are not here concerned, but with such striking objects as the stars, for the observation of which the ancients, under their favoring skies, had far better opportunity than ourselves; and which, furthermore, were to them of the greatest practical importance, both on land and sea, before the discovery of the mariner's compass. Yet the elder Pliny states the number of observed stars, i. e., of the stars according to him visible to the naked eye, as only 1,600; while Argelander reckoned 3,256; and Heis, to whom the stars appeared as points without rays, added to the last figure 2,000 more. To all this add the fact that the ancients, owing to their living in lower latitudes, could survey a larger portion of the celestial sphere than we can [in Germany]. The stars noted by the ancients decrease in number as they rise in the order of magnitudes, though, in fact, each successive class of magnitudes embraces more stars than all the preceding classes taken together. Of nebulæ and star-clusters, five were known to Ptolemy; Argelander saw nineteen with the naked eye. Hipparchus and Ptolemy take no note of the nebula in Orion, or of that in Andromeda. But the most striking circumstance of all, perhaps, is the fact that the ancients did not count the Pleiades correctly, though their number was matter of dispute, and hence an object of keener ob-

servation, and though that constellation was of importance to them in determining the seasons.[1] According to Aratus, who flourished under the successors of Alexander, there are only six Pleiades, and it is a vulgar error to admit that they were seven, and that one of them was lost. Hipparchus, however, corrected Aratus, and fixed the number of the Pleiades at seven. Nevertheless, Ovid says of the Pleiades:

"Quæ septem dici, sex tamen esse solent;"[2]

—and the poets went on speaking of a lost Pleiad.[3] But nowadays ordinary observers, with good eyesight, can discern fourteen to sixteen stars in this constellation.

The ancients, then, according to Littrow, described the heavens as imperfectly as though they had been to some extent short-sighted, or as though—but this supposition is negatived by other facts—the discriminating power of the human retina had since become more acute. On the other hand, we cannot sufficiently admire the refinement of their artistic sense in reproducing the forms of the human body. In counting the Pleiades they erred. But the wavy lines of female beauty have never been rendered with greater perfection than by them; and the Borghese Gladiator gives evidence in every one of his quivering muscles of such close observation as to lead to the supposition that in the ancient art-schools there was an esoteric teaching of anatomy.[4] It is customary to attribute the supreme skill of the ancient sculptors in representing the human body to the advantages they enjoyed, as compared with our own artists, who can only study professional models, in frequently viewing the nude in unconstrained action in gymnasia and at the public games. But, with respect to the female figure, the ancient sculptors had no such great advantage over our own, and yet here, too, they have attained unequaled excellence. So, too, our artists have as fair opportunity of studying the breast of a live, nude horse as the ancients had of observing nude athletes; and yet it was said, during the lifetime of Franz Krüger, that he was the only artist who knew how to paint a horse's breast. The truth is, that the ancients had a special inclination for this kind of observation, but it lay altogether outside their habits of thought nicely to determine the limits of a phenomenon as regards space, time, and weight. Hence, in all that concerns artistic forms their eye was very highly developed, but they lacked the training needed for grasping scientific facts.

They were utter strangers to the art of experimentation, wherein methodical observation under arbitrarily determined conditions combines with a fervid inventive imagination and a calm judgment to pro-

[1] Whewell, "History of the Inductive Sciences, vol. i., p. 130, London, 1847.

[2] "Which are said to be seven, though they are but six." Ovid gives two mythological hypotheses for the disappearance of the seventh Pleiad, "Fasti," lib. iv., v. 170–178.

[3] *Cf.* Byron's "Beppo," stanza xiv.

[4] Salvage, "Anatomie du Gladiateur combattant applicable aux Beaux-Arts," 1812, p. iv.

duce a purely modern form of mental activity, which oftentimes not only leads to certitude in the experimental science, but even evokes new phenomena. Thales already was acquainted with "the soul of amber," and the power of the Heracleian Stone was well known to the ancients as a matter of simple curiosity. But they never got beyond the first crude observation of those effects out of which the modern mind has developed a whole world of facts and ideas.

In the time of Alexander the Great, however, interest in remarkable natural curiosities was so far developed that he used to send back from his expeditions such objects to his teacher Aristotle. But how little was done later by the Romans toward utilizing the unparalleled opportunities they enjoyed for increasing the knowledge of Nature! From every quarter of their immense empire they gathered animals for their vulgar shows and feasts. At enormous expense they raised all manner of animals for food. We read, too, of their aviaries. But we learn nothing of any establishment in Rome for exhibiting plants and animals—a managerie or a botanic garden—such as we find even among the Aztecs.[1]

Without scientific observation, experiment, and sound theory, no enduring progress can be made in the useful arts. Such progress necessarily depends on conscious utilization of natural forces observed in their orderly workings. Of this, on the whole, the ancients had no idea. True, they carried to a high state of perfection some few branches of useful art. In architecture, road-making, and bridge-building, in bronze-casting and the art of cutting precious stones, they were masters. The art of fortification and the siege enginery of the later Romans are truly wonderful. But, if we would estimate aright the degree of technical skill reached by the ancients, we must compare it with the results attained by other nations. The technical skill wherein they excelled belongs to a comparatively low grade of culture. In architecture, for instance, the Egyptians, too, as well as the Assyrians, the Hindoos, and even the Peruvians under the Incas, were very proficient. A much higher degree of culture is marked by the invention of the mariner's compass, gunpowder, and printing. Next comes the steam-engine, an invention which we owe to modern European civilization.

The second of these stages of technical evolution the ancients never attained. On the other hand, it was reached at a comparatively early date by the civilized peoples of Eastern Asia, who, in other respects, seem barbarous as compared with the Greeks and Romans. These Asiatics, it is true, only employed the compass on land-journeys, used gunpowder only for fireworks, and they did not in printing employ movable types, owing to the clumsiness of their mode of writing. But, even in their pottery and textile fabrics, the classic nations were surpassed by the Hindoos, the Chinese, and the Japanese. The ancient civilization always stood, so to speak, with one foot in the bronze age.

[1] Prescott, "Conquest of Mexico," vol. i., p. 124, *et seq.*; vol. ii., pp. 60, 108, *et seq.*

To get an idea of the tardiness of their progress in the useful arts, we might compare the difference in material culture between the time of Pericles and that of Constantine on the one hand, and between Barbarossa's time and our own on the other. All industrial occupations among the ancients were, for the most part, confined to the servile class. This is the reason often assigned for the low state of industrial art among them. But may we not rather recognize, in the contempt of the freemen for industrial occupation, their small capacity for the same? However this may be, the material culture of the ancients evinces a one-sidedness and an imperfectness corresponding to the deficiencies we have already found to exist in their theoretical culture.

Hence comes the disproportion between technical and æsthetic performance, so often noticed in the products of ancient art-industry. In our museums, every one admires the candelabra brought from the villas of wealthy Romans, which were destroyed by the eruption of Vesuvius. From light bronze branches, whose leaves seem to flutter in every breath of air, are suspended by slender chains a number of beautifully-fashioned lamps. By the light of these lamps Cæsar wrote his "Commentaries," Cicero rounded his periods, Horace gave the last polish to his "Odes." Each lamp is simply an oil-holder, into which dips a wick—a smoky affair, that no scullery-girl would tolerate nowadays. The idea of discovering the source of the light given by the lamp; of finding it in a more or less perfect combustion of a combination rich in carbon—a combustion carried only so far that, in the hot but not luminous flame produced by perfect combustion, some solid carbon-particles shall be brought to a white heat; of bringing about this degree of combustion by regulating the supply of air and oil; meantime, of protecting the flame from air-currents, saving the surrounding objects from smut, and guarding the organ of smell from the offensive odors of acrolein—such thoughts never once appear to have occurred to the minds of the artists of Magna Græcia. For them, the most perfect lamp was the one that was the most ornamental. If more light was needed, other smudgy lamps were added.

Thus the ancient culture resembled one of those coins on which a master-hand had stamped a noble countenance of some deity, but which he could not make round. We may, therefore, justly characterize this civilization as being essentially æsthetic, and the attitude of the ancients toward Nature as *speculative and æsthetic.*

The backwardness of the ancients in natural science was fruitful in most serious consequences to the human race. It was one of the chief reasons of the downfall of the old civilization. The greatest misfortune that ever befell humanity, namely, the overrunning of the Mediterranean countries by the barbarians, could have been prevented had the ancients possessed natural science as we understand that term.

This point has not, perhaps, been sufficiently noted hitherto. When Montesquieu and Gibbon described the fall of the Roman Empire, nat-

ural science had not attained its present importance in the minds of modern nations, and even to this day it is for the most part overlooked by writers of history. The numerous causes under the action of which the Roman Empire was destined to crumble to pieces, and to become the prey of the barbarians, have been again and again set forth with much learning and skill. No doubt the ancient world had grievous internal ills. Slavery, pretorianism, corruption of morals, and aversion to matrimony, decay of civic as also of military virtue, the enervation caused by over-refinement, which had exhausted every pleasure and profaned every ideal, and which could not find in itself the means of rising above itself—such are the oft-cited causes to which the inevitable downfall of the Roman domination is ascribed.

And yet the success which almost invariably attended the efforts of vigorous emperors is proof that the state of affairs was not entirely hopeless. Down even to a very late period of the empire's history, the course of events was tolerably amenable to control and regulation, and in the face of the enemy the legions did not altogether belie their hereditary valor and discipline. Even in the palmiest days of the Roman state they had not always been victorious. The introduction of Christianity did not move the ancient world out of the ruts so much as might have been expected. Though a portion of the ancient culture was then thrown overboard, it nevertheless, on the whole, remained intact. There yet stood, under the protection of the victorious cross, temples, theatres, baths, halls of justice; the multitude of the works of art baffled the fury of the destroyers, and the papyrus rolls of the libraries still preserved unscathed the treasures which a thousand years had collected. What was needed was to oppose to the inpouring barbarian hosts from the northeast a barrier which should last until the tide had begun to ebb, and these hordes had themselves come under the influence of civilization: then all would have been well.

It was the opinion of Liebig, who also contemplated the downfall of the ancient culture from the point of view of the natural sciences, that the case was hopeless, whatever might be done. As a result of his researches on mineral manures, Liebig taught that the Roman Empire fell like the Grecian communities at an earlier day, and like the Spanish domination later, because in the countries from which the Romans derived their grain the soil had become exhausted of the mineral matters requisite for growing wheat, especially of phosphoric acid and potash.[1] This doctrine was refuted by Conrad, who shows that the fact of the soil having been exhausted is not proved. In every instance where, according to Liebig, the soil was exhausted by improvident cropping, other reasons may be assigned for the decreased fertility; for instance, drought resulting from the decay of irrigation-works, or from reckless deforestation, and the production of marshes from the want of river-

[1] "Die Chemie in ihrer Anwendung auf Agricultur und Physiologie," "*Einleitung in die Naturgesetze des Feldbaues*," p. 86, *et seq.*

levees, or the sinking of the soil by volcanic action. Many a tract of waste-land in Italy, which in former times was thickly populated, would still be productive were it not that the dragon of malaria keeps watch on the golden fleece of the grain-harvest. The south of Spain did not become barren till after Christian intolerance had driven out the industrious Moors, and Gothic laziness had permitted their irrigation-canals to become choked up. Wherever, therefore, sterility was not produced by irresistible natural agencies, it was not the cause, but rather the result, of the decay of the state. Under more favorable political conditions, the ancient fertility of the soil might be restored, but the evils of deforestation, as we see in Provence, can hardly ever be repaired.

It was not because the soil of the Mediterranean countries was impoverished in phosphoric acid and potash that the ancient civilization went to ruin, but because that civilization was built on the quicksand of æsthetics and speculativism, which was quickly swept away by the tide of barbarian invasion. Suppose the legionaries had been armed with flint-lock muskets, instead of the *pilum*, and that, instead of the catapult and the *ballista*, the Romans possessed even such artillery as was employed during the sixteenth century. Would not all the migrant hordes, from the Cimbri and the Teutones down to the Vandals, have been sent back home with broken heads? True, the Romans beat back the Teutones with the *pilum* alone, for, even with equal arms on both sides, the superior military science, backed by higher mental and bodily development, ever prevails over undisciplined masses of men. But, had fire-arms taken the place of the *pilum*, the Romans would always have triumphed over the barbarians, even without a Marius, and without such terrible efforts as at Aquæ Sextiæ. It is vain to speculate in history about what would have happened under altered circumstances. So much, however, is clear, that, had not the ancients neglected to win for themselves that absolute mastery over brute force which the subjugation of Nature and the progressive improvement of industrial skill always insure, the two ethnic elements of the "Nibelungenlied," namely, Northern heroes and horsemen from the steppes of Asia, would have been powerless against the Roman Empire, though its rottenness stunk to heaven. And, had the ancients developed their inventiveness sufficiently to originate the art of printing, then, despite the invasions of the barbarians, we should not have to lament evermore the loss of so many a masterpiece of poet, orator, and historian.

IV.—The Scholastico-Ascetic Period.

But the ancient culture succumbed. The night of the middle ages settled down upon those shores of the Mediterranean once illumined with the splendor of all that is grand and beautiful. To this was added a peculiar fatality which made the intellectual ruin more complete, and

entirely checked for a long time the progress of natural science which under the ancients had been tardy enough.

With the fall of Roman power came, at the same time, the fall of polytheism, a system dating from the anthropomorphic period of the Philosophy of Nature. Christianity now came into possession of Olympus, crowded with barbaric gods, and banished its denizens to the region of demons and ghosts. Nor was it content with such purification of the temple as this. Sprung itself from Judaism, which possessed neither art nor science, but which was already characterized by an exclusive estimate of the value of moral effort, the new creed restricted the circle of ideas, which alone it recognized as profitable to man, within the categories of *good* and *bad*, and the relations between the sinful creature and his creator. In opposition to heathenism, which was languishing from sensuous excess, it enjoined on its adherents self-denial and contempt of earthly life, and bade them to tremble in constant expectation of the judgment which was to come both for them and for the whole world. This earth, with all its glory, appeared henceforth to man as a resting-place unworthy of notice, where the soul must prepare for a better state to come. Our body, given to us in love by father and mother, this crown and masterpiece of creation, Christianity despised as the perishable shell of the soul which alone was akin to God; nay, it hated the body as the accursed source of sin. Only with fear and trembling could the believer pluck the fruit of the tree of life. A celibate life within the walls of a cloister, and entirely occupied with prayer and penances, was held to be the best way, and the one most pleasing to God, of spending the time of trial here below; in recompense, the elect were assured of sempiternal beatitude *post mortem*.

That this new mode of looking at the universe was little favorable to natural science is obvious. Still it is only with difficulty that we can form to ourselves an idea of the attitude of the human mind toward Nature during the middle ages. A passage from the life of Francesco Petrarca will serve to throw light upon this point.

Petrarca, in whom the reminiscences of classic antiquity awoke and were strangely blended with the beliefs of his own day, daily had in sight, from Avignon, Mont Ventoux, that uttermost spur of the maritime Alps, swept by the *mistral*. Long had he wished to stand upon its summit. His longing was stimulated on reading in Livy that Philip of Macedon (the enemy of the Romans) ascended Mount Hæmus, in Thrace,[1] in order to view simultaneously the Adriatic and the Euxine. At last, on the 26th of April, 1336, the plan was carried into execution, and, as the weather was very favorable, Petrarca and his younger brother, Gherardo, enjoyed the broad prospect. The clouds beneath his feet proved to him the possibility of what he had often read of before with incredulity with regard to Athos and Olympus. The distant chain

[1] Titi Livii, "Hist. Rom.," lib. xxx., 21, 22. Petrarca falls into the error, not before noted, as far as I am aware, of planting Mount Hæmus (the Balkans) in Thessaly.

of the Alps calls to his mind Hannibal, and beyond he descries, with the mind's (rather than the bodily) eye, the land for which he longed—Italy. But now he feels the fetters which bind him growing painfully tighter; the image of his mysterious lady below there in Avignon, and whom he had for the first time seen almost exactly nine years before, April 6, 1327, rises before his mind. Of the Ovidian verse which he uses to describe the state of his feelings—

"Odero si potero. Si non, invitus amabo"[1]—

we can hardly say that it expresses a great amount of passion. The grandeur of the surrounding spectacle, the Rhône at his feet, in the distance the flashing mirror of the Mediterranean between Marseilles and Aigues Mortes, bring him back again to the real world. While he abandons himself to these impressions, it occurs to him to open, as though it had been a "book of fate," a little copy of St. Augustine's "Confessions" which he always carried about with him. He read there this passage: "Men go to gaze on lofty mountains and the mighty waves of the sea, and the wide currents of rivers, and the vast extent of ocean, and the circling courses of the stars, and they overlook themselves."[2] Taken in connection with the context, the passage does not carry an ascetic meaning, but occurs in the course of a theoretical explanation of memory that rather does credit to the mystic Bishop of Hippo. But Petrarca sees in these words, so directly applicable to his surroundings at that moment, the very finger of God. Full of shame and remorse, and without uttering another word, he descends from the mountain, and that very night addresses to his confessor, Dionigi de' Roberti, the doleful letter from which we take this narrative. The poor fellow had for a moment, forgetful of his soul's welfare, indulged the harmless pleasure of looking out on the entrancing world of sense, when he should have been moodily contemplating his own inner state. So diseased were the intellectual faculties of man in Europe in that age, that this incident sufficed to bring a conscientious, fine-feeling, but not very strong-minded man like Petrarca into a state of intensely painful self-conflict.

Fortunately, the "Decamerone" shows that not all minds were so delicately strung. But in the "Divina Commedia" we curiously enough see a poetic imagination of the highest power, equipped with all the scientific lore of its day, clothing the ascetic view of the world in such a garb of stern reality, that King John of Saxony has been able, from the description given in the "Inferno," to sketch a topographical plan of hell, as though Virgil had conducted, not a poet, but a scientific

[1] "Amores," lib. iii., Eleg. x., v. 35. "If I can, I will hate; if not, I shall love against my will."

[2] This incident occurred in the thirty-second year of the poet's life. The passage from Augustine is as follows in the original: "Et eunt homines admirari alta montium, et ingentes fluctus maris, et latissimos lapsus fluminum, et oceani ambitum, et gyros siderum, et relinquunt seipsos."

traveler—a Leopold von Buch, for instance—through the infernal regions.

It was not only by depreciating in the estimation of mankind the world of phenomena that Christianity, during this dreary period, discouraged the study of Nature, but also by proposing to them new and peculiar aims, before unheard of. Amid a darkness of their own procuring, men busied themselves with such problems that to them might well have been addressed the reproof of *Romeo* to *Mercutio:* "Peace, peace! thou talk'st of nothing." The best minds of the time expended no end of labor and ingenuity in distinguishing between absurdity and nonsense. Like a plant in the dark, the ancient philosophy put forth colorless and weakly sprouts which sought the light mainly in two directions, platonistic tendencies finding expression in an insane gnosticism, and Aristotelian tendencies in barren scholasticism. Scholasticism held the ground longest, and the *scholastico-ascetic period* will always remain as a warning to show to what length the unaided human mind, divorced from the world of reality, and without the revelation of Nature, can go astray.

V.—The Rise of Modern Science.

Inasmuch as humanity recovered from this madness through the study of the ancients, revived by Petrarca and Boccaccio, the next ensuing stage of development is called the stage of humanism. In the dusty codices the mind of the Christian West, awakened as it were from a bewildering dream, got a glimpse of the grand old heathen world; and, hardly believing its own eyes, began to understand how deplorably narrow was the circle of ideas within which it had in some unaccountable way suffered itself to be confined for a thousand years. A flood of reawakened ideas coursed through school and castle and town, and even through the cloisters; and, as it might be increased, swept away the musty trumpery of mediæval hallucination. With the ideas of the ancients, their works of art, too, arose from the grave. To the newly-awakened antique spirit corresponded the new form of the beautiful; and in an instant, almost, art flourished as it never has flourished since, with a bloom which is to the bloom of Hellenic art what a flower, perhaps of less perfect form, but of heavenly sweet odor, is to a flower of perfect beauty but odorless.

This resurrection of the human mind, with its natural consequences—the reformation of the Church, and the new birth of philosophy and the other sciences of mind—has oftentimes been described at length. Still, one point has commonly been overlooked, which it is not so easy satisfactorily to deduce. As we have seen, the ancients knew nothing of natural science, in our sense of the term. Is it not, then, a very curious circumstance that the resuscitation of classical studies should have given the impulse to the development of modern natural science?—that the ancients, who themselves could not think scientifically, nor

experiment, nor even observe, should now, by their teaching and by their ideas, produce a race in whom these faculties were to go on steadily and incessantly developing—a race bearing to the authors of its intellectual culture the same relation as subsists between a brood of ducks and the hen that has hatched them out? To what cause, then, do modern civilized peoples owe the victorious outburst of the instinct of causality which among the ancients found no adequate or methodical expression, or was satisfied with futile reasons? Must we say that among the Kelts and Germans, who soon vied with the Latin peoples in their ardor to share in this newly-awakened intellectual activity, this instinct was naturally stronger than among the Greeks and Romans? And was, perhaps, Keltic or Germanic blood mingled with Tuscan in the veins of the youth who, during mass, discovered the isochronism of the pendulum oscillations in Buschetto's cathedral?

The greater seclusion and introspection of northern life, the quiet and leisure of the monasteries, the exigencies of a ruder climate, are cited as conditions that would naturally dispose the modern civilized nations toward investigation of Nature and the manufacturing arts. But if we trace backward the course of modern science, we at last find many clews leading into the laboratories of the alchemists and the observatories of the astrologers; and here, as we know, we meet with Arabian philosophy as a new element of culture.

While beneath the sign of the Cross the night of barbarism was settled down on the Western world, in the East, under the green standard of the Prophet, an original form of civilization had been developed, which not only preserved what had been won by the classical peoples in mathematics, astronomy, and medicine, but even itself made no mean acquisitions in those sciences. Through the crusaders and the Spanish Moors, this civilization had in many ways reacted on Europe, and it is natural for us to seek here for the source of those new ideas which the mind of the Western nations, reawakened by the writings of the ancients, could not have drawn from those writings. The question arises, "Whence did the Arabs derive their stronger instinct of causality, as compared with the Greeks and Romans?" Was that intelligent race specially gifted for observation and investigation of facts? Such a supposition conflicts with all we know of Semitic habits of thought, which incline more toward the exercise of dialectical subtilty, fanciful imagining, and speculative meditation.

But for the momentary ascendency of natural science under the influence of Islam, as also for its development in the Christian West so soon as the ban of the scholastic philosophy had been broken, a profounder reason can with some probability be assigned, and one which covers both of these cases. This reason, it is true, is ultimately based on an ethno-psychological peculiarity of the Semitic race. That race, not only directly, through the labors of its Arabic branch, had a part in the creation of modern science, but indirectly, too, the Semites were

founders of modern science, owing to the fact that with them originated the monotheistic religions. Modern natural science, paradoxical as the statement is, owes its origin to Christianity.

Between polytheism and monotheism there is this difference, that the former is essentially tolerant, the latter essentially intolerant. Socrates apparently fell the victim of religious zeal, but, as we know, political considerations, and his uncomplying behavior toward his judges, had most influence in procuring his condemnation. At the time of the Acts of the Apostles the Athenians paid worship even to unknown gods, lest any deity should be slighted. The Roman Pantheon admitted all gods, even the gods of conquered nations. The Christians were persecuted by the Roman emperors solely because they were esteemed to be dangerous to the state. On the other hand, Judaism, Christianity, and Islam, have imagined that they each alone possessed the saving faith, and, in a measure, the idea of an absolute truth only came into the world through them. As the Greeks and Romans recognized all sorts of strange gods in addition to their own, and as the Semitic parable of the three rings would have been amiss among them, so, too, with regard to scientific truth, they were not over-particular. Their undeveloped instinct of causality was satisfied when they could assign for a phenomenon some ingenious explanation which pleased the fancy; and their researches of ultimate causes consisted really only of delightful conversations about what appeared admissible. "What is truth?" asked the Roman magistrate, in derision. "I came into the world to bear witness to the truth," said Jesus, and allowed himself to be crucified.

The idea of a God who suffers no other gods beside him, who appears not as a human invention involved in unworthy fables, but as the highest, the absolute Being, who is the centre of all man's moral aspirations, and who with unerring omniscience notes every transgression —this idea of God, entertained for hundreds of years by generation after generation of men, accustomed the mind of man, even in scientific matters, to the thought that throughout the universe the cause of things is one only, and inspired him with the wish to know this cause. Faust's heart-felt cry—

"Du musst, du musst, und kostet' es mein Leben!"[1]

is one quite foreign to the spirit of the ancient world. The fearful earnestness of a religion which claimed for itself all knowledge, which threatened its adversaries with everlasting torture in the next world, and claimed the right even in this life of visiting them with the most horrible punishment, imparted to humanity in the lapse of centuries that character of sobriety and of profundity which certainly fitted them better for patient research than did the light-hearted joy of life favored by the heathen religions. Where so many martyrs were teach-

[1] "Thou must, thou must, though it cost me my life!"

ing men how they should die for their creed, there must also be those who were ready for science' sake to lead a life of self-denial, or even, if need were, to die for it. In inspiring man with the ardent longing for absolute knowledge, Christianity made atonement for the wrongs its asceticism had for so long done to science.

RECENT EXPERIMENTS ON FOG-SIGNALS.

By Professor JOHN TYNDALL, F.R.S.

OUR most intense coast-lights, including the six-wick lamp, the Wigham gaslight, and the electric light, being intended to aid the mariner in heavy weather, may be regarded, in a certain sense, as fog-signals. But fog, when thick, is intractable to light; the sun cannot penetrate it, much less any terrestrial source of illumination. Hence the necessity of employing sound-signals in dense fogs. Bells, gongs, horns, guns, and sirens, have been used for this purpose; but it is mainly, if not wholly, explosive signals that I have now to submit to the notice of the Society. During the long, laborious, and, I venture to think, memorable series of observations conducted under the auspices of the Elder Brethren of the Trinity House at the South Foreland in 1872 and 1873, it was proved that a short 5¼-inch howitzer, firing 3 pounds of powder, yielded a louder report than a long 18-pounder firing the same charge. Here was a hint to be acted on by the Elder Brethren. The effectiveness of the sound depended on the shape of the gun, and as it could not be assumed that in the howitzer we had hit accidentally upon the best possible shape, arrangements were made with the War Office for the construction of a gun specially calculated to produce the loudest sound attainable from the combustion of 3 pounds of powder. To prevent the unnecessary landward waste of the sound, the gun was furnished with a parabolic muzzle, intended to project the sound over the sea, where it was most needed. The construction of this gun was based on a searching series of experiments executed at Woolwich with small models, provided with muzzles of various kinds. The gun was constructed on the principle of the revolver, its various chambers being loaded and brought in rapid succession into the firing position. The performance of the gun proved the correctness of the principles on which its construction was based.

It had been a widely-spread opinion among artillerists, that a bronze gun emits a specially loud report. I doubted from the outset whether this would help us; and in a letter dated April 22, 1874, ventured to express myself thus: "The report of a gun, as affecting an observer close at hand, is made up of two factors—the sound due to the shock of the air by the violently expanding gas, and the sound derived from

the vibrations of the gun, which, to some extent, rings like a bell. This latter, I apprehend, will disappear at considerable distances." The result of subsequent trial, as reported by General Campbell, is,

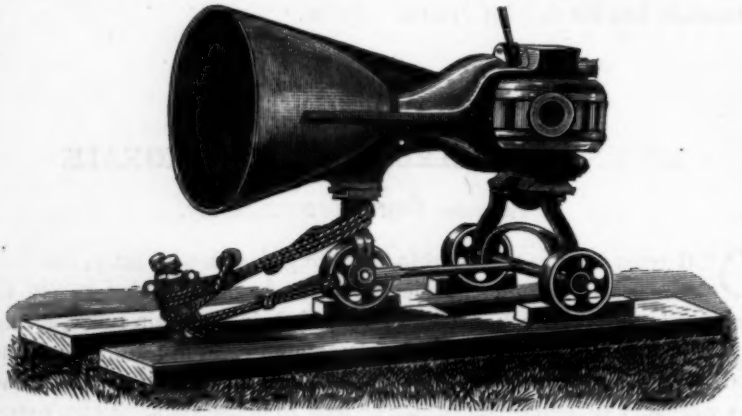

FIG. 1.—BREECH-LOADING FOG-SIGNAL GUN, WITH BELL-MOUTH, PROPOSED BY MAJOR MAITLAND, R. A., ASSISTANT SUPERINTENDENT.

that "the sonorous qualities of bronze are greatly superior to those of cast-iron at short distances, but that the advantage lies with the baser metal at long ranges."[1]

Coincident with these early trials of guns at Woolwich, gun-cotton was thought of as a probably effective sound-producer. Theoretic considerations caused me to fix my attention persistently on this substance; for the remarkable experiments of Mr. Abel, whereby its rapidity of combustion and violently explosive energy are demonstrated, seemed to single it out as a substance eminently calculated to fulfill the conditions necessary to the production of an intense wave of sound. What those conditions are we shall now more particularly inquire, calling to our aid a brief but very remarkable paper, published by Prof. Stokes in the *Philosophical Magazine* for 1868.

The explosive force of gunpowder is known to depend on the sudden conversion of a solid body into an intensely heated gas. The work which the artillerist requires the expanding gas to perform is the displacement of the projectile. Such, however, is not the work that we want our gunpowder to perform. We wish it to transmute its energy not into the mere mechanical translation of the shot, but into vibratory motion. We want *pulses* to be formed which shall propagate themselves to vast distances through the atmosphere, and this requires a certain choice and management of the explosive material.

[1] General Campbell assigns a true cause for this difference. The ring of the bronze gun represents so much energy withdrawn from the explosive force of the gunpowder. Further experiments would, however, be needed to place the superiority of the cast-iron gun at a distance beyond question.

A sound-pulse consists essentially of two parts—a condensation and a rarefaction. Now, air is a very mobile fluid, and, if the shock imparted to it lack due promptness, the pulse is not produced. Consider the case of a common clock-pendulum, which oscillates to and fro, and which therefore might be expected to generate corresponding pulses in the air. When, for example, the bob moves to the right, the air to the right of it might be supposed to be condensed, while a partial vacuum might be supposed to follow the bob. As a matter of fact, we have nothing of this kind. The air-particles in front of the bob retreat so rapidly, and those behind it close so rapidly in, that no sound-pulse is formed. A tuning-fork which executes 256 complete vibrations in a second, if struck gently on a pad and held in free air, emits a scarcely audible note. It behaves to some extent like the pendulum-bob. This feebleness is due to the prompt "reciprocating flow" of the air between the incipient condensations and rarefactions, whereby the formation of sound-pulses is forestalled. Stokes, however, has taught us that this flow may be intercepted by placing the edge of a card in close proximity to one of the corners of the fork. An immediate augmentation of the sound of the fork is the consequence.

The more rapid the shock imparted to the air, the greater is the fractional part of the energy of the shock converted into wave-motion. And, as different kinds of gunpowder vary considerably in their rapidity of combustion, it may be expected that they will also vary as producers of sound. This theoretic inference is completely verified by experiment. In a series of preliminary trials conducted at Woolwich on the 4th of June, 1875, the sound-producing powers of four different kinds of powder were determined. In the order of size of grain they bear the names respectively of Fine-grain (F. G.), Large-grain (L. G.), Rifle Large-grain (R. L. G.), and Pebble-powder (P.), (Fig. 2). The charge in each case

FIG. 2.

amounted to 4½ pounds.; four 24-pound howitzers being employed to fire the respective charges. There were eleven observers, all of whom, without a single dissentient, pronounced the sound of the fine-grain powder loudest of all. In the opinion of seven of the eleven the large-grain powder came next; seven also of the eleven placed the rifle large-grain third on the list; while they were again unanimous in pronouncing the pebble-powder the worst sound-producer. These differences

are entirely due to differences in the rapidity of combustion. All who have witnessed the performance of the 80-ton gun at Woolwich must have been surprised at the mildness of its thunder. To avoid the strain resulting from quick combustion, the powder employed is composed of lumps far larger than those of the pebble-powder above referred to. In the long tube of the gun these lumps of solid matter gradually resolve themselves into gas, which on issuing from the muzzle imparts a kind of push to the air, instead of the sharp shock necessary to form the condensation of an intensely sonorous wave.

These are some of the physical reasons why gun-cotton might be regarded as a promising fog-signal. Firing it as we have been taught to do by Mr. Abel, its explosion is more rapid than that of gunpowder. In its case the air-particles, alert as they are, will not, it might be presumed, be able to slip from places of condensation to places of rarefaction with a rapidity sufficient to forestall the formation of the wave. On *a priori* grounds, then, we are entitled to infer the effectiveness of gun-cotton, while in a great number of comparative experiments, stretching from 1874 to the present time, this inference has been verified in the most conclusive manner.

On the 22d of February, 1875, a number of small guns, cast specially for the purpose—some with plain, some with conical, and some with parabolic muzzles, firing 4 ounces of fine-grain powder—were pitted against 4 ounces of gun-cotton, detonated both in the open and in the focus of a parabolic reflector.[1] The sound produced by the gun-cotton, reënforced by the reflector, was unanimously pronounced loudest of all. With equal unanimity, the gun-cotton detonated in free air was placed second in intensity. Though the same charge was used throughout, the guns differed not among themselves, but none of them came up to the gun-cotton, either with or without the reflector. A second series, observed from a different distance on the same day, confirmed to the letter the foregoing result.

As a practical point, however, the comparative cost of gun-cotton and gunpowder has to be taken into account, though considerations of cost ought not to be stretched too far in cases involving the safety of human life. In the earlier experiments, where quantities of equal price were pitted against each other, the results were somewhat fluctuating. Indeed, the perfect manipulation of the gun-cotton required some preliminary discipline—promptness, certainty, and effectiveness of firing, augmenting as experience increased. As 1 pound of gun-cotton costs as much as 3 pounds of gunpowder, these quantities were compared together on the 22d of February. The guns employed to discharge the gunpowder were a 12-pound brass howitzer, a 24-pound cast-iron howitzer, and the long 18-pounder used at the South Foreland. The result recorded is, that the 24-pound howitzer, firing 3 pounds of

[1] For charges of this weight the reflector is of moderate size, and may be employed without fear of fracture.

gunpowder, had slight advantage over 1 pound of gun-cotton detonated in the open; while the 12-pound howitzer and the 18-pounder were both beaten by the gun-cotton. On the 2d of May, on the other hand, the gun-cotton is reported as having been beaten by all the guns.

Meanwhile, the parabolic muzzle gun (Fig. 3), expressly intended for fog-signaling, was pushed rapidly forward, and on the 22d and 23d of March, 1876, its power was tested at Shoeburyness. Pitted against it were a 16-pounder, a 5½-inch howitzer, 1½ pound of gun-cotton detonated in the focus of a reflector, and 1½ pound of gun-cotton detonated

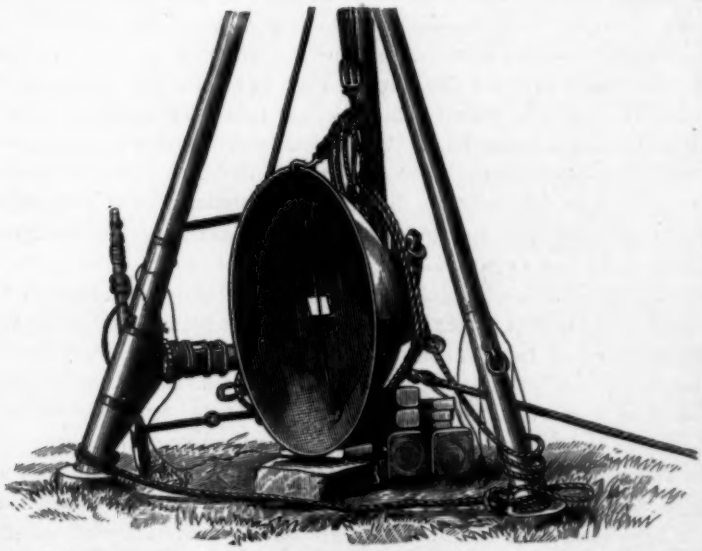

FIG. 3.—GUN-COTTON SLAB (1½ LB.) DETONATED IN THE FOCUS OF A CAST-IRON REFLECTOR.

in free air. On this occasion, nineteen different series of experiments were made, when the new experimental gun, firing a 3-pound charge, demonstrated its superiority over all guns previously employed to fire the same charge. As regards the comparative merits of the gun-cotton fired in the open, and the gunpowder fired from the new gun, the mean values of their sounds were found to be the same. Fired in the focus of the reflector, the gun-cotton clearly dominated over all the other sound-producers.[1]

The whole of the observations here referred to were embraced by an angle of about 70°, of which 50° lay on the one side and 20° on the other side of the line of fire. The shots were heard by eleven observers on board the Galatea, which took up positions varying from 2 miles to 13½ miles from the firing-point. In all these observations, the reënforcing action of the reflector, and of the parabolic muzzle of the gun, came into

[1] In this case the reflector was fractured by the explosion, but it did good service after fracture.

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[1] For charges of this weight the reflector is of moderate size, and may be employed without fear of fracture.

gunpowder, had slight advantage over 1 pound of gun-cotton detonated in the open; while the 12-pound howitzer and the 18-pounder were both beaten by the gun-cotton. On the 2d of May, on the other hand, the gun-cotton is reported as having been beaten by all the guns.

Meanwhile, the parabolic muzzle gun (Fig. 3), expressly intended for fog-signaling, was pushed rapidly forward, and on the 22d and 23d of March, 1876, its power was tested at Shoeburyness. Pitted against it were a 16-pounder, a 5½-inch howitzer, 1½ pound of gun-cotton detonated in the focus of a reflector, and 1½ pound of gun-cotton detonated

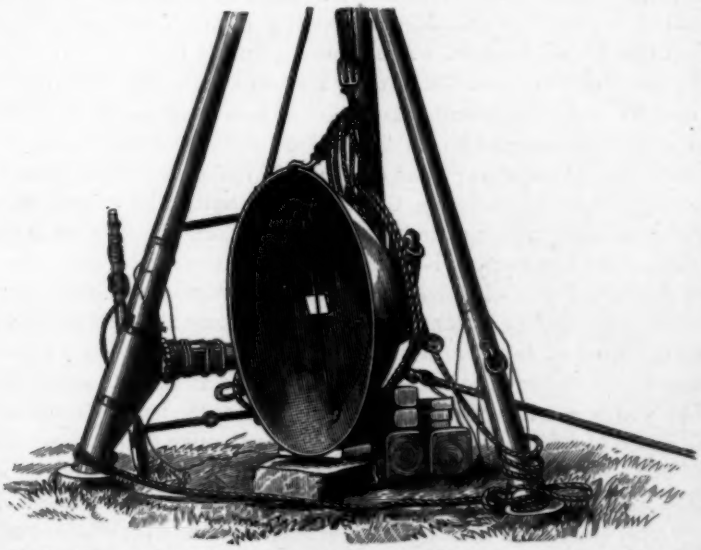

FIG. 3.—GUN-COTTON SLAB (1½ LB.) DETONATED IN THE FOCUS OF A CAST-IRON REFLECTOR.

in free air. On this occasion, nineteen different series of experiments were made, when the new experimental gun, firing a 3-pound charge, demonstrated its superiority over all guns previously employed to fire the same charge. As regards the comparative merits of the gun-cotton fired in the open, and the gunpowder fired from the new gun, the mean values of their sounds were found to be the same. Fired in the focus of the reflector, the gun-cotton clearly dominated over all the other sound-producers.[1]

The whole of the observations here referred to were embraced by an angle of about 70°, of which 50° lay on the one side and 20° on the other side of the line of fire. The shots were heard by eleven observers on board the Galatea, which took up positions varying from 2 miles to 13½ miles from the firing-point. In all these observations, the reënforcing action of the reflector, and of the parabolic muzzle of the gun, came into

[1] In this case the reflector was fractured by the explosion, but it did good service after fracture.

play. But the reënforcement of the sound in one direction implies its withdrawal from some other direction, and accordingly it was found that at a distance of 5¼ miles from the firing-point, and on a line including nearly an angle of 90° with the line of fire, the gun-cotton in the open beat the new gun; while behind the station, at distances of 8½ miles and 13½ miles respectively, the gun-cotton in the open beat both the gun and the gun-cotton in the reflector. This result is rendered more important by the fact that the sound reached the Mucking Light, a distance of 13½ miles, against a light wind which was blowing at the time.

Most, if not all, of our ordinary sound-producers send forth waves which are not of uniform intensity throughout. A trumpet is loudest in the direction of its axis. The same is true of a gun. A bell, with its mouth pointed upward or downward, sends forth waves far denser in the horizontal plane passing through the bell than at an angular distance of 90° from that plane. The oldest bell-hangers must have been aware of the fact that the sides of the bell, and not its mouth, emitted the strongest sound, their practice being determined by this knowledge. Our slabs of gun-cotton also emit waves of different densities in different parts. It has occurred in the experiments at Shoeburyness that when the broad side of a slab was turned toward the suspending wire of a second slab six feet distant, the wire was cut by the explosion, while, when the edge of the slab was turned to the wire, this never occurred. To the circumstance that the broad sides of the slabs faced the sea is probably to be ascribed the remarkable fact observed on the 23d of March, that in two directions, not far removed from the line of fire, the gun-cotton detonated in the open had a slight advantage over the new gun.

Theoretic considerations rendered it probable that the shape and size of the exploding mass would affect the constitution of the wave of sound. I did not think large rectangular slabs the most favorable shape, and accordingly proposed cutting a large slab into fragments of different sizes, and pitting them against each other. The differences between the sounds were by no means so great as the differences in the quantities of explosive material might lead one to expect. The mean values of eighteen series of observations made on board the Galatea, at distances varying from 1¾ mile to 4.8 miles, were as follows:

Weights.....	4-ounce	6-ounce	9-ounce	12-ounce	7-ounce rocket.
Value of sound....	3.12	3.34	4.0	4.03	3.35

These charges were cut from a slab of dry gun-cotton about 1¾ inch thick; they were squares and rectangles of the following dimensions: 4 ounces, 2 inches by 2 inches; 6 ounces, 2 inches by 3 inches; 9 ounces, 3 inches by 3 inches; 12 ounces, 2 inches by 6 inches.

The numbers under the respective weights express the recorded value of the sounds. They must be simply taken as a ready means of expressing the approximate relative intensity of the sounds as estimated by the ear. When we find a 9-ounce charge marked 4, and a 12-ounce charge marked 4.03, the two sounds may be regarded as practically equal

in intensity, an addition of 30 per cent. in the larger charges producing no sensible difference in the sound. Were the sounds estimated by some physical means, instead of by the ear, the values of the sound would not, in my opinion, show a greater advance with the increase of material than that indicated by the foregoing numbers. Subsequent experiments rendered still more certain the effectiveness, as well as the economy, of small charges of gun-cotton.

It is an obvious corollary from the foregoing experiments that on our "nesses" and promontories, where the land is clasped on both sides for a considerable distance by the sea—where, therefore, the sound has to propagate itself rearward as well as forward—the use of the parabolic gun, or of the parabolic reflector, might be a disadvantage rather than an advantage. Here gun-cotton, exploded in the open, forms a most appropriate source of sound. This remark is especially applicable to such lightships as are intended to spread the sound all round them as from central foci. As a signal in rock-lighthouses, where neither siren, steam-whistle, nor gun, could be mounted, and as a handy fleet-signal, dispensing with the lumber of special signal-guns, the gun-cotton will prove invaluable. But in most of these cases we have the drawback that local damage may be done by the explosion. The lantern of the rock-lighthouse might suffer from concussion near at hand, and though mechanical arrangements might be devised, both in the case of the lighthouse and of the ship's deck, to place the firing-point of the gun-cotton at a safe distance, no such arrangement could compete, as regards simplicity and effectiveness, with the expedient of a *gun-cotton rocket.* Had such a means of signaling existed at the Bishop's Rock Lighthouse, the ill-fated Schiller might have been warned of her approach to danger ten, or it may be twenty, miles before she reached the rock which wrecked her. Had the fleet possessed such a signal, instead of the ubiquitous but ineffectual whistle, the Iron Duke and Vanguard need never have come into collision.

It was the necessity of providing a suitable signal for rock lighthouses, and of clearing obstacles which cast an acoustic shadow, that suggested the idea of the gun-cotton rocket to Sir Richard Collinson, Deputy Master of the Trinity House. That idea was to place a disk or short cylinder of the gun-cotton in the head of a rocket, the ascensional force of which should be employed to cary the disk to an elevation of 1,000 feet or thereabouts, where, by the ignition of a fuse associated with a detonator, the gun-cotton should be fired, sending its sound in all directions vertically and obliquely down upon earth and sea. The first attempt to realize this idea was made on the 18th of July, 1876, at the firework manufactory of the Messrs Brock, at Nunhead. Eight rockets were then fired, four being charged with 5 ounces and four with 7½ ounces of gun-cotton. They ascended to a great height, and exploded with a very loud report in the air. On the 27th of July, the rockets were tried at Shoeburyness, the most noteworthy result on

this occasion being the hearing of the rockets at the Mouse Lighthouse, 8¼ miles east by south, and at the Chapman Lighthouse, 8½ miles west by north; that is to say, at opposite sides of the firing-point. It is worthy of remark that, in the case of the Chapman Lighthouse, land and trees intervened between the firing-point and the place of observation. "This," as General Younghusband justly remarked at the time, "may prove to be a valuable consideration if it should be found necessary to place a signal-station in a position whence the sea could not be freely observed." Indeed, the clearing of such obstacles was one of the objects which the inventor of the rocket had in view.

On the 13th of December, 1876, and again on the 8th of March, 1877, comparative experiments on firing at high and low elevations were executed. The gun-cotton near the ground consisted of ½-pound disks suspended from an horizontal iron bar about 4½ feet above the ground. The rockets carried the same quantity of gun-cotton in their heads, and the height to which they attained, as determined by a theodolite, was from 800 to 900 feet.

The latter day was cold, with occasional squalls of snow and hail, the direction of the sound being at right angles to that of the wind. Five series of observations were made on board the Vestal, at distances varying from 3 to 6 miles. The mean value of the explosions in the air exceeded that of the explosions near the ground by a small but sensible quantity. At Windmill Hill, Gravesend, however, which was nearly to leeward, and 5½ miles from the firing-point, in nineteen cases out of twenty-four the disk fired near the ground was loudest, while in the remaining five the rocket had the advantage. Toward the close of the day the atmosphere became very serene. A few distant cumuli sailed near the horizon, but the zenith and a vast angular space all round it were absolutely free from cloud. From the deck of the Galatea a rocket was discharged, which reached a great elevation, and exploded with a loud report. Following this solid nucleus of sound was a continuous train of echoes, which retreated to a continually greater distance, dying gradually off into silence after seven seconds' duration. These echoes were of the same character as those so frequently noticed at the South Foreland in 1872–'73, and called by me "aërial echoes."

On the 23d of March the experiments were resumed, the most noteworthy results of that day's observations being that the sounds were heard at Tillingham, 10 miles to the northeast; at West Mersea, 15¾ miles to the northeast by east; at Brightlingsea, 17½ miles to the northeast; and at Clacton Wash, 20½ miles to the northeast by ½ east. The wind was blowing at the time from the southeast. Some of these sounds were produced by rockets, some by a 24-pound howitzer, and some by an 8-inch maroon.

In December, 1876, Mr. Gardiner, the managing director of the Cotton-Powder Company, had proposed a trial of this material against

the gun-cotton. The density of the cotton, he urged, was only 1.03, while that of the powder was 1.70. A greater quantity of explosive material being thus compressed into the same volume, Mr. Gardiner thought that a greater sonorous effect must be produced by the powder. At the instance of Mr. Mackie, who had been in communication previously with the Deputy Master of the Trinity House and myself, a committee of the Elder Brethren visited the cotton-powder manufactory, on the banks of the Swale, near Faversham, on the 16th of June, 1877. The weights of cotton-powder employed were 2 ounces, 8 ounces, 1 pound, and 2 pounds, in the form of rockets and of signals fired a few feet above the ground. The experiments throughout were arranged and conducted by Mr. Mackie. Our desire on this occasion was to get as near to windward as possible, but the Swale and other obstacles limited our distance to 1½ mile. We stood here east-southeast from the firing-point, while the wind blew fresh from the northeast.

The cotton-powder yielded a very effective report. The rockets in general had a slight advantage over the same quantities of material fired near the ground. The loudness of the sound was by no means proportional to the quantity of the material exploded, 8 ounces yielding very nearly as loud a report as 1 pound. The "aërial echoes," which invariably followed the explosion of the rockets, were loud and long-continued, shading off, as in all previous cases, by imperceptible gradations, into silence.

On the 17th of October, 1877, another series of experiments with howitzers and rockets was carried out at Shoeburyness. The charge of the howitzer was 3 pounds of L. G. powder. The charges of the rockets were 12 ounces, 8 ounces, 4 ounces, and 2 ounces, of gun-cotton respectively. The gun and the four rockets constituted a series, and eight series were fired during the afternoon of the 17th. The observations were made from the Vestal and the Galatea, positions being assumed which permitted the sound to reach the observers with the wind, against the wind, and across the wind. The distance of the Galatea varied from 3 to 7 miles, that of the Vestal, which was more restricted in her movements, being 2 to 3 miles. Briefly summed up, the result is that the howitzer, firing a 3-pound charge, which it will be remembered was our best gun at the South Foreland, was beaten by the 12-ounce rocket, by the 8-ounce rocket, and by the 4-ounce rocket. The 2-ounce rocket alone fell behind the howitzer.

It is worth while recording the distances to which some of the sounds were heard on the day now referred to:

1. Leigh	6½	miles	west-northwest	24	out of 40	sounds	heard.
2. Girdler Light-vessel	12	"	southeast by east	5	"	"	
3. Reculvers	17½	"	southeast by south	18	"	"	
4. St. Nicholas	20	"	southeast	3	"	"	
5. Epple Bay	22	"	southeast by east	19	"	"	
6. Westgate	23	"	southeast by east	9	"	"	
7. Kingsgate	25	"	southeast by east	8	"	"	

The day was cloudy, with occasional showers of drizzling rain; the wind about northwest by north all day; at times squally, rising to a force of 6 and 7 and sometimes dropping to a force of 2 or 3. The station at Leigh excepted, all these places were to leeward of Shoeburyness. At four other stations to leeward, varying in distance from 15½ to 24½ miles, nothing was heard, while at eleven stations to windward, varying from 8 to 26 miles, the sounds were also inaudible. It was found, indeed, that the sounds proceeding against the wind did not penetrate much beyond 3 miles.

On the following day, viz., the 18th of October, we proceeded to Dungeness with the view of making a series of strict comparative experiments with gun-cotton and cotton-powder. Rockets containing 8 ounces, 4 ounces, and 2 ounces of gun-cotton had been prepared at the Royal Arsenal; while others, containing a similar quantity of cotton-powder, had been supplied by the Cotton-Powder Company at Faversham. With these were compared the ordinary 18-pounder gun, which happened to be mounted at Dungeness, firing the usual charge of 3 pounds of powder.

From these experiments it appeared that the gun-cotton and cotton-powder were practically equal as producers of sound.

The effectiveness of small charges was also illustrated in a very striking manner, only a single unit separating the numerical value of the 8-ounce rocket from that of the 2-ounce rocket. The former was recorded as 6.9 and the latter as 5.9, the value of the 4-ounce charge being intermediate between them. These results were recorded by a number of very practised observers on board the Galatea. They were completely borne out by the observations of the coast-guard, who marked the value of the 8-ounce rocket 6.1, and that of the 2-ounce rocket 5.2. The 18-pounder gun fell far behind all the rockets, a result probably to be in part ascribed to the imperfection of the powder. The performance of the siren was, on the whole, less satisfactory than that of the rockets. The instrument was worked, not by steam of 70 pounds pressure, as at the South Foreland, but by compressed air, beginning with 40 pounds and ending with 30 pounds pressure. The trumpet was pointed to windward, and in the axis of the instrument the sound was about as effective as that of the 8-ounce rocket. But in a direction at right angles to the axis, and still more in the rear of this direction, the siren fell very sensibly behind even the 2-ounce rocket.

These are the principal comparative trials made between the gun-cotton rocket and other-fog signals; but they are not the only ones. On the 2d of August, 1877, for example, experiments were made at Lundy Island, with the following results: At 2 miles distant from the firing-point, with land intervening, the 18-pounder, firing a 3-pound charge, was quite unheard. Both the 4-ounce rocket and the 8-ounce rocket, however, reached an elevation which commanded the acoustic shadow, and yielded loud reports. When both were in view, the rockets were

still superior to the gun. On the 6th of August, at St. Ann's, the 4-ounce and 8-ounce rockets proved superior to the siren. On the Shambles Light-vessel, when a pressure of 13 pounds was employed to sound the siren, the rockets proved greatly superior to that instrument. Proceeding along the sea-margin at Flamborough Head, Mr. Edwards states that at a distance of 1¼ mile, with the 18-pounder gun hidden behind the cliffs, its report was quite unheard, while the 4-ounce rocket, rising to an elevation which brought it clearly into view, yielded a powerful sound in the face of an opposing wind.

On the evening of February 9, 1877, a remarkable series of experiments was made by Mr. Prentice, at Stowmarket, with the gun-cotton rocket. From the report with which he has kindly furnished me I extract the following particulars. The first column in the annexed statement contains the name of the place of observation, the second its distance from the firing-point, and the third the result observed:

Stoke Hill, Ipswich.....	10 miles	Rockets clearly seen and sounds distinctly heard 53 minutes after the flash.
Melton.....	15 "	Signals distinctly heard. Thought at first that sounds were reverberated from the sea.
Framlingham.....	18 "	Signals very distinctly heard, both in the open air and in a closed room. Wind in favor of sound.
Stratford. St. Andrews....	19 "	Reports loud; startled pheasants in a cover close by.
Tuddenham. St. Martin ...	10 "	Reports very loud; rolled away like thunder.
Christ Church Park.....	11 "	Report arrived a little more than a minute after flash.
Nettlested Hall.....	6 "	Distinct in every part of observer's house. Very loud in the open air.
Bildestone.....	6 "	Explosion very loud, wind against sound.
Nacton.....	14 "	Reports quite distinct—mistaken by inhabitants for claps of thunder.
Alboro.....	25 "	Rockets seen through a very hazy atmosphere; a rumbling detonation heard.
Capel Mills.....	11 "	Reports heard within and without the observer's house. Wind opposed to sound.
Lawford.....	15½ "	Reports distinct: attributed to distant thunder.

In the great majority of these cases, the direction of the sound inclosed a large angle with the direction of the wind. In some cases, indeed, the two directions were at right angles to each other. It is needless to dwell for a moment on the advantage of a signal commanding ranges such as these.

The explosion of substances in the air, after having been carried to a considerable elevation by rockets, is a familiar performance. In 1873 the Board of Trade actually proposed a light-and-sound rocket as a signal of distress, which proposal was subsequently realized, but in a form too elaborate and expensive for practical use. The idea of the gun-cotton rocket with a view to signaling in fogs is, I believe, wholly due to

the Deputy Master of the Trinity House. Thanks to the skillful aid given by the authorities of Woolwich, by Mr. Prentice and Mr. Brock, that idea is now an accomplished fact; a signal of great power, handiness, and economy, being thus placed at the service of our mariners. Not only may the rocket be applied in association with lighthouses and light-ships, but in the navy also it may be turned to important account. Soon after the loss of the Vanguard, I ventured to urge upon an eminent naval officer the desirability of having an organized code of fog-signals for the fleet. He shook his head doubtingly, and referred to the difficulty of finding room for signal-guns. The gun-cotton rocket completely surmounts this difficulty. It is manipulated with ease and rapidity, while its discharges may be so grouped and combined as to give a most important extension to the voice of the admiral in command. It is needless to add that at any point upon our coasts, or upon any other coast, where its establishment might be desirable, a fog-signal station might be extemporized without difficulty.

I have referred more than once to the train of echoes which accompanied the explosion of gun-cotton in free air, speaking of them as similar in all respects to those which were described for the first time in my report on fog-signals, addressed to the Corporation of Trinity House in 1874.[1] To these echoes I attached a fundamental significance. There was no visible reflecting surface from which they could come. On some days, with hardly a cloud in the air, and hardly a ripple on the sea, they reached us with magical intensity. They came directly from the body of the air in front of the great trumpet which produced them. The trumpet-blasts were five seconds in duration, but long before the blast had ceased the echoes struck in, adding their strength to the primitive note of the trumpet. After the blast had ended the echoes continued, retreating farther and farther from the point of observation, and finally dying away at great distances. The echoes were perfectly continuous as long as the sea was clear of ships, "tapering" by imperceptible gradations into absolute silence. But when a ship happened to throw itself athwart the course of the sound, the echo from the broadside of the vessel was returned as a shock which rudely interrupted the continuity of the dying atmospheric music.

These echoes have been ascribed to reflection from the crests of the sea-waves. But this hypothesis is negatived by the fact that the echoes were produced in great intensity and duration when no waves existed —when the sea, in fact, was of glassy smoothness. It has been also shown that the direction of the echoes depended not on that of waves, real or assumed, but on the direction of the axis of the trumpet. Causing that axis to traverse an arc of 210°, and the trumpet to sound at various points of the arc, the echoes were always, at all events in calm weather, returned from that portion of the atmosphere toward which the trumpet was directed. They could not, under the circum-

[1] *See* also "Philosophical Transactions" for 1874, p. 183.

stances, come from the glassy sea; while both their variation of direction and their perfectly continuous fall into silence are irreconcilable with the notion that they came from fixed objects on the land. They came from that portion of the atmosphere into which the trumpet poured its maximum sound, and fell in intensity as the direct sound penetrated to greater atmospheric distances.

The day on which our latest observations were made was particularly fine. Before reaching Dungeness, the smoothness of the sea and the serenity of the air caused me to test the echoing power of the atmosphere. A single ship lay about half a mile distant between us and the land. The result of the proposed experiment was clearly foreseen. It was this: The rocket being sent up, it exploded at a great height; the echoes retreated in their usual fashion, becoming less and less intense as the distance of the surfaces of reflection from the observers increased. About five seconds after the explosion, a single loud shock was sent back to us from the side of the vessel lying between us and the land. Obliterated for a moment by this more intense echo, the aërial reverberation continued its retreat, dying away into silence in two or three seconds afterward.

I have referred to the firing of an 8-ounce rocket from the deck of the Galatea, on March 8, 1877, stating the duration of its echoes to be seven seconds. Mr. Prentice, who was present at the time, assured me that, in his experiments with rockets, similar echoes had been frequently heard of more than twice this duration. The ranges of his sounds alone would render this result in the highest degree probable.

To attempt to interpret an experiment which I have not had an opportunity of repeating is an operation of some risk; and it is not without a consciousness of this that I refer here to a result considered adverse to the notion of aërial echoes. When the trumpet of a siren is pointed toward the zenith, it is alleged that when the siren is sounded no echo is returned. Now, the reflecting surfaces which give rise to these echoes are for the most part due to differences of temperature between sea and air. If, through any cause, the air above be chilled, we have descending streams—if the air below be warmed, we have ascending streams as the initial cause of atmospheric flocculence. A sound proceeding vertically does not cross the streams, nor impinge upon the reflecting surfaces, as does a sound proceeding horizontally across them. Aërial echoes, therefore, will not accompany the vertical sound as they accompany the horizontal one. The experiment, as I interpret it, is not opposed to the theory of aërial echoes which I have ventured to enunciate. But, as I have indicated, not only to see, but to vary such an experiment, is a necessary prelude to grasping its full significance.

In a paper published in the "Philosophical Transactions" for 1876, Prof. Osborne Reynolds refers to these echoes in the following terms: "Without attempting to explain the reverberations and echoes which

have been observed, I will merely call attention to the fact that in no case have I heard any attending the reports of the rockets,[1] although they seem to have been invariable with the guns and pistols. These facts suggest that the echoes are in some way connected with the direction given to the sound. They are caused by the voice, trumpets, and the siren, all of which give direction to the sound; but I am not aware that they have ever been observed in the case of a sound which has no direction of greatest intensity."

The reference to the voice and other references cause me to think that, in speaking of echoes, Prof. Osborne Reynolds and myself are dealing with different phenomena. Be that as it may, the foregoing observations render it perfectly certain that the condition as to direction here laid down is not necessary to the production of the echoes.

There is not a feature connected with the aërial echoes which cannot be brought out by experiments in the laboratory. I have recently made the following experiment: A rectangle, 22 inches by 12, is crossed by 23 brass tubes, each having a slit along it from which gas can issue. In this way, 23 low, flat flames are obtained. A sounding reed, fixed in a short tube, is placed at one end of the rectangle, and a sensitive flame at some distance beyond the other end. When the reed sounds, the flame in front of it is violently agitated, and roars boisterously. Turning on the gas, and lighting it as it issues from the slits, the air above the flames becomes so heterogeneous that the sensitive flame is instantly stilled by the aërial reflection, rising from a height of 6 inches to a height of 18 inches. Here we have the acoustic opacity of the air in front of the South Foreland strikingly imitated. Turning off the gas, and removing the sensitive flame to some distance behind the reed, it burns there tranquilly, though the reed may be sounding. Again lighting the gas as it issues from the brass tubes, the sound reflected from the heterogeneous air throws the sensitive flame into violent agitation. Here we have imitated the aërial echoes heard when standing behind the siren-trumpets at the South Foreland. The experiment is extremely simple, and in the highest degree impressive.

WATER-SUPPLY OF RIVERS.

By GEORGE CHAHOON.

IN the year 1871, three kilns were built on lot 54, Jay Tract, town of Wilmington, Essex County, New York, for the purpose of burning wood into charcoal, to be used in making iron in the Catalan forges, on the Ausable River. At the time these kilns were built, the side of the mountain upon which they are located was covered with a heavy

[1] These carried 12 ounces of gunpowder.

growth of spruce-timber. Near the top of the mountain there is a pond, covering about one acre of ground. This pond was undoubtedly scooped out on the southeast side of the mountain during the Glacial period, and at the outlet the water is confined by a wide, low moraine dam, such as, upon a larger scale, distinguish all our moraine lakes. This pond, some 2,000 feet above the level of the sea, forms the head or source of a small trout-brook that flows down the side of the mountain past where the kilns have been erected.

I first visited this pond in August, 1874, and was very curious to know where the water came from, for I could not understand how the small extent of country drained could supply so much water during such a warm, dry time.

In the summer of 1876, after a thousand acres of timber had been cut, a fire broke out in the woods, not only killing the standing timber, but destroying the corded wood in the kiln-yard, and doing considerable other damage.

It was part of my business to prevent this destruction, as far as possible. Men were sent to the fire, and worked there for several days. In going to the kilns, the road leads up the mountain, by the side of the brook. The season was very dry, and the water in the rivers unusually low; but, in going up the mountain, I was surprised to notice that there was as much water in this brook as I had ever seen, except after some long, heavy rains, and my judgment in this matter was confirmed by all the men working at the kilns, with whom I spoke on the subject.

The fire was very fierce, and, after leaving the standing timber, spread across the cleared ground, burning the soil as far down as it was dry; and it actually ran through a field of potatoes freshly hoed, leaving the half-grown, scorched, and burned potatoes, lying upon the top of the ground. This fire lasted several days, and I was at the kilns every day during its continuance, and was every day surprised that the brook, fed largely from the drainage of the burning land, seemed to increase with the fierceness and extent of the fire. In some places, when cleared land had been burned over and dried under the scorching sun, in one or two days afterward the fire ran over it again, taking off another shaving of soil. This continued until the fire was finally quenched by rain.

Afterward, in making an examination of the soil, I found that it consisted of from two to four feet of what is known among the woodsmen of Northern New York as "spruce-duff," which is composed of rotten spruce-trees, cones, needles, etc. This "duff" has the power of holding water almost equal to the sponge, and, when it is thoroughly dry, burns, like punk, without a blaze.

I was told by Mr. Cooper, who has the direct charge of the kilns, that, in sledding wood down the mountain, the sleds frequently wore off the "duff," and came to ice.

On June 30, 1876, while the fire was still burning, I tested the water

and soil, as far down as I could conveniently dig with my hands, with a thermometer, and found a temperature of from 37° to 40° Fahr. I afterward dug down, in several places, through the "duff," and in each place found ice or frozen ground.

After this, it was perfectly clear to my mind that this "duff" became thoroughly saturated with water during the fall rains, and that it was frozen to the bottom during the long, severe winters of this climate. It is not an uncommon thing for the ground in the valleys, hundreds of feet below the level of these kilns, to freeze to the depth of four feet during the winter.

The "duff" being frozen at the bottom accounts for the brook increasing in size with the increase of the fire, for the heat from the burning of the top "duff" would cause the ice to melt, and the water would find its way into the brook. This "duff," like all woody substances, is a poor conductor of heat, and when once frozen and protected, as it is in its natural state by the shade of the timber, would thaw out very slowly, and would continue to furnish a supply of water all summer; and very hot weather, causing low water in other places, would tend to increase the supply from this source.

During the latter part of the summer of 1877 I examined "duff" in several places, but did not find any ice; but found the "duff," in every instance, thoroughly saturated with water. It should be remembered that the summer of 1877 was unusually wet, and that water is an excellent conductor of heat, and that water from the rains, running over the ice, would melt it much sooner than it could be melted by what heat could be communicated from the sun, through its woody covering, in a dry season. At most, this would tend to show that the ice lasts only part of the summer, but, if that is a fact, the frozen "duff" would furnish a reservoir as long as the ice lasted, and, during the rest of the summer, would act as an absorbent, taking up and holding the showers, and gradually letting the water down into the streams, tending to prevent floods after heavy rains by holding back the water, and preventing scarcity of water during droughts by gradually releasing the water gathered from the storms.

In addition to the "duff," the sides of many of our mountains are covered with a heavy moss, which also acts as a sponge in the manner described above, in preventing floods and supplying water during dry seasons; and this moss, like the "duff," entirely disappears when the land is cleared, and, like the "duff," does not form again under the pines and deciduous trees that follow the spruce. The spruce-timber affords a dense shade, and, as long as the timber is left standing, this "duff" seldom gets dry enough to burn, but, when the timber is cut, the top of the "duff" dries, and is burned, as far down as it is dry enough to burn, by the forest-fires that are so common in this part of the country. This is repeated, year after year, until the "duff" is all burned off, and the sand and bowlders appear upon the surface; after

this, white poplar and white birch spring up, which, however, are liable to be burned at any time, as the fire runs freely through all deciduous timber in the spring, before the leaves are out, or during a very dry time in summer.

It is generally understood that the clearing away of the forests has the effect of causing low water during the summer season, and the reasons given for it are, the more rapid evaporation of water from the soil, on account of the greater exposure to the sun in cleared than in timbered land, and to this may be added the more rapid drainage, particularly in sandy soils, after the rotten logs, leaves, and other absorbents, have been removed; and it is also claimed that more rain falls upon a section of country when it is timbered than after the land has been cleared. The first of these reasons is undoubtedly correct, and there is a great deal to show that the second is correct also, though I do not think we know enough about the subject to justify us in stating, as a scientific fact, that the amount of rainfall is affected by the growth of timber.

I have never known the existence of the spruce "duff" to be recognized, as a fact of any importance, in governing our water-supply during dry seasons; but, unless I am greatly in error, it is a matter of the greatest importance, and the destruction of the "duff," with the destruction of the forests, will prove as damaging to our streams as the increased evaporation caused by the greater exposure of the land to the sun.

The waters from this immediate section of country flow into Lake Champlain, and thence into the St. Lawrence River. The country around the principal feeders of the Hudson River is almost identical with the country described above, and the same causes that affect the water-supply of the Saranac and Ausable govern the water-supply of the Hudson.

The water-supply of the Hudson is a matter of very great importance to the people of New York, and any facts tending to throw light upon the natural laws governing it should be received with interest by the intelligent people whose health, comfort, and prosperity, are partially dependent upon the quantity and purity of the water in this noble river. Hundreds of square miles of the country upon whose drainage the Hudson is dependent for its supply of water is covered with this "spruce-duff," which, in the early spring, is a solid body of ice, holding untold millions of gallons of the purest water, to be slowly thawed out and given up to this river during the summer. In many places, and in most seasons, part of this ice lasts through the whole summer; in most places it lasts well into the summer, and even after the ice is gone the "duff" absorbs and stores away the rain, and, like a prudent housewife with her confections, gives up her treasures in such a way as not to injure the health of her children with her lavishness, nor exhaust her larder before a fresh supply can reasonably be expected.

I am convinced that careful investigation will demonstrate that the preservation of the "duff" is another and a very important reason why the destruction of the forests around the head-waters of the Hudson should be discontinued.

EVOLUTION OF CEREMONIAL GOVERNMENT.

By HERBERT SPENCER.

VI. FORMS OF ADDRESS.

WHAT the obeisance implies by acts, the form of address says in words. If the two have a common root, this is to be anticipated; and that they have a common root is demonstrable. Instances occur in which the two are used indifferently, as being the one equivalent to the other. Speaking of Poles and Slavonic Silesians, Captain Spencer remarks:

> "Perhaps no distinctive trait of manners more characterizes both than their humiliating mode of acknowledging a kindness, their expression of gratitude being the servile "Upadam do nog" (I fall at your feet), which is no figure of speech, for they will literally throw themselves down and kiss your feet for the trifling donation of a few halfpence."

Here, then, the attitude of the conquered man beneath the conqueror is either actually assumed or verbally assumed; and, when used, the oral representation is a substitute for the realization in act. Other cases show us words and deeds similarly associated: as when a Turkish courtier, accustomed to make humble obeisances, addresses the sultan, "Centre of the Universe! Your slave's head is at your feet;" or as when a Siamese, whose servile prostrations occur daily, says to his superior, "Lord Benefactor, at whose feet I am;" to a prince, "I the sole of your foot;" to the king, "I a dust-grain at your sacred feet." Still better when a Siamese attendant on the king says, "High and excellent lord of me thy slave, I ask to take the royal commands, and to place them on my brain, on the top of my head," we have verbally indicated that absolutely-subject attitude in which the head is under the victor's foot.

Nor are there wanting instances from nearer countries showing this substitution of professed for performed obeisances. In Russia, even in these days of moderated despotism, a petition begins with the words, "So-and-so strikes his forehead" (on the ground); and petitioners are called "forehead-strikers." At the court of France, as late as 1577, it was the custom of some to say, "I kiss your grace's hands," and of others to say, "I kiss your lordship's feet." Even at the present time in Spain, where Orientalisms descending from the past still linger, we read: "When you get up to take leave, if of a lady, you should say,

'My lady, I place myself at your feet;' to which she will reply, 'I kiss your hand, sir.'"

From what has gone before, such origins and such characters of forms of address might, indeed, be anticipated. Along with other ways of propitiating the victor, the master, and the ruler, will naturally come speeches which, beginning with confessions of defeat by verbal assumption of its attitude, will develop into varied phrases acknowledging the state of servitude. The implication, therefore, is that forms of address in general, descending as they do from these originals, will express, clearly or vaguely, ownership by, or subjection to, the person addressed.

Of propitiatory speeches, there are some which, instead of describing the prostration entailed by defeat, describe the resulting state of being at the mercy of the person addressed. One of the strangest of these occurs among the cannibal Tupis. While on the one hand a warrior shouts to his enemy, "May every misfortune come upon thee, my meat!" on the other hand the speech required from the captive Hans Stade on approaching a dwelling was, "I, your food, have come." A verbal surrender of life takes other forms in other places. It is asserted that, during ancient times in Russia, petitions to the czar commenced with the words, "Do not order our heads to be cut off, O mighty lord, for presuming to address you, but hear us!" And, though I do not get direct verification for this statement, it receives indirect support from the still-current saying, "Whoso goes to the czar risks his head," as also from the lines—

"My soul is God's,
My land is mine,
My head's the Czar's,
My back is thine!"

Then, again, instead of professing to live only by permission of the superior, actual or pretended, who is spoken to, we find the speaker professing to be personally a chattel of his, or to be holding property at his disposal, or both. Africa, Polynesia, and Europe, furnish examples. "When a stranger enters the house of a Serracolet (inland negro), he goes out and says, 'White man, my house, my wife, my children, belong to thee.'" In the Sandwich Islands a chief, asked respecting the ownership of a house or canoe possessed by him, replies, "It is yours and mine." In France, in the fifteenth century, a complimentary speech made by an abbé on his knees to the queen when visiting a monastery was, "We resign and offer up the abbey with all that is in it, our bodies, as our goods." And at the present time in Spain, where politeness requires that anything admired by a visitor shall be offered to him, "the correct place of dating [a letter] from should be .... from this *your* house, wherever it is; you must not say from this

my house, as you mean to place it at the disposition of your correspondent."

But these modes of addressing a real or fictitious superior, indirectly asserting subjection to him in body and effects, are secondary in importance to the direct assertions of slavery and servitude; which, beginning in barbarous days, have persisted during civilization down to the present time.

Biblical narratives have familiarized us with the word "servant," as habitually applied to himself by a subject or inferior, when speaking to a ruler or superior. In our days of freedom, the associations established by daily habit have obscured the fact that "servant," as used in translations of old records, means "slave"—implies the condition fallen into by a captive taken in war. Consequently, when, as frequently in the Bible, the phrases "thy servant" or "thy servants" are uttered before a king, they must be taken to signify that same state of subjugation which is more circuitously signified by the phrases quoted in the last section. Clearly this self-abasing word was employed, not by attendants only, but by conquered peoples, and by subjects at large; as we see when the unknown David, addressing Saul, describes both himself and his father as Saul's servants. And kindred uses of the word to rulers have continued down to modern times.

Very early, however, professions of servitude, originally made only to one of supreme authority, came to be made to those of subordinate authority. Brought before Joseph in Egypt, and fearing him, his brethren call themselves his servants or slaves; and not only so, but speak of their father as standing in a like relation to him. Moreover, there is evidence that this form of address extended to the intercourse between equals, where a favor was to be gained; as witness Judges xix. 19. How among European peoples a like diffusion has taken place, need not be shown further than by exemplifying some of the stages. Among French courtiers in the sixteenth century it was common to say, "I am your servant and the perpetual slave of your house;" and among ourselves in past times there were used such indirect expressions of servitude as—"Yours to command," "Ever at your worship's disposing," "In all serviceable humbleness," etc. While in our days, rarely made orally save in irony, such forms have left only their written representatives—"Your obedient servant," "Your humble servant:" mostly reserved for occasions when distance is to be maintained, and for this reason often having inverted meanings.

That for religious purposes the same propitiatory words are used, is a familiar truth. In Hebrew history men are described as servants of God, just as they are described as servants of the king. Neighboring peoples are said to serve their respective deities just as slaves are said to serve their masters. And there are sundry cases in which these relations to the visible ruler and to the invisible ruler are expressed in par-

allel ways; as where we read that "the king hath fulfilled the request of his servant," and elsewhere that "the Lord hath redeemed his servant Jacob." Hence, as now used in worship, the expression "thy servant" has a history parallel to the histories of all other elements of religious ceremonial.

And here, perhaps, better than elsewhere, may be noted the fact that the phrase "thy son," used to a ruler, or superior, or other person, is originally equivalent to "thy servant." When we remember that in the rudest societies children exist only on sufferance of their parents, and that in patriarchal groups, whence the civilized societies of Europe have descended, the father had life and death power over his children, we see that professing to be another's son was like professing to be his servant or slave. There are ancient instances showing us the equivalence; as when "Ahaz sent messengers to Tiglath-pileser, King of Assyria, saying, I am thy servant and thy son: come up, and save me." And we are not without more modern instances, furnished by those mediæval times when, as we have seen, rulers offered themselves for adoption by more powerful rulers: so assuming the condition of filial servitude and calling themselves sons; as did Theodebert I. and Childebert II. to the Emperors Justinian and Maurice. Nor does there lack evidence that in some places this expression of subordination spreads like the rest, until it becomes a complimentary form of speech. "A Samoan cannot use more persuasive language than to call himself the son of the person addressed."

From those complimentary phrases which express abasement of self, we pass to those which exalt another person. Either kind taken alone is a confession of relative inferiority; and this confession becomes the more emphatic when the two kinds are joined, as they ordinarily are.

At first it does not seem likely that words of eulogy may, like other propitiations, be traced back to the behavior of the conquered to the conqueror; but we are not without proof that they do thus originate, certainly in some cases. To the victorious Rameses II. his defeated foes preface their prayers for mercy by the laudatory words—"Prince guarding thy army, valiant with the sword, bulwark of his troops in day of battle, king mighty of strength, great Sovran, Sun powerful in truth, approved of Ra, mighty in victories, Rameses Miamon." Obviously there is no separation between such praises uttered by the vanquished and those subsequently coming from them as a permanently-subjugated people, or those commonly made by subjects to their militant and despotic rulers. We pass without break to glorifying words like those addressed to the King of Siam—"Mighty and august lord! Divine Mercy!" "The Divine Order!" "The Master of Life!" "Sovereign of the Earth!" etc.: or like those addressed to the sultan —"The Shadow of God!" "Glory of the Universe!" or like those addressed to the Chinese Emperor—"Son of Heaven!" "The Lord of

Ten Thousand Years!" or like those some two years since addressed by the Bulgarians to the Emperor of Russia—"O blessed Czar!" "Blissful Czar!" "Orthodox powerful Czar!" or like those with which, in the past, speeches to the French monarch commenced—"O very benign! O very great! O very merciful!" And then along with these propitiations by direct flattery there go others in which the flattery is indirectly conveyed by affected admiration of whatever the ruler says: as when the courtiers of the King of Delhi held up their hands, crying, "Wonder, wonder!" after any ordinary speech: or in broad day, if he said it was night, responded, "Behold the moon and the stars!" or as when Russians in past times exclaimed, "God and the prince have willed!" "God and the prince know!"

Eulogistic phrases, first thus used to supreme men, of course descend to men in less authority, and so downward. Illustrations are supplied by those current in France during the sixteenth century—to a cardinal, "the very illustrious and very reverend;" to a bishop, "the very reverend and very illustrious;" to a duke, "the very illustrious and very reverend lord, my much-honored master;" to a marquis, "my very illustrious and much-honored lord;" to a doctor, "the virtuous and excellent." And from our own past days may be added such complimentary forms of address to those of lower rank as—"the right worshipful," to knights and sometimes to esquires; "the right noble," "the honorable-minded," used to gentlemen; and, even to aldermen and men addressed as Mr., such laudatory prefixes as "the worthy and worshipful," "the worshipfull, vertuous, and most worthy." Along with flattering epithets there spread flatteries more involved in form, especially observable in the East, where both are extreme. On a Chinese invitation-card the compliment, gravely addressed to an ordinary person, is—"To what an elevation of splendor will your presence assist us to rise!" Tavernier, from whom I have quoted the above example of scarcely credible flattery from the court of Delhi, adds, "This vice passeth even unto the people;" and, instancing the way in which he was himself classed with ancient men of the most transcendent powers, adds that even his military attendant, compared to the greatest of conquerors, was described as making the world tremble when he mounted his horse: a description harmonizing with the instance Mr. Roberts gives of Oriental compliment to an ordinary person—"My lord, there are only two who can do anything for me: God is the first, and you are the second."

On reading that in Tavernier's time a usual expression in the East was—"Let the king's will be done," recalling the parallel expression—"Let God's will be done," we are reminded that various of the glorifying speeches addressed to kings are identical with those addressed to deities. Where the militant type is highly developed, and where divinity is ascribed to the monarch, not only after death but before, as of old in Egypt and Peru, and as now in Japan, China, and Siam, it naturally results that the words of eulogy addressed to the visible ruler

and the ruler who has become invisible are substantially the same. Having reached the extreme of hyperbole to the king when living, they cannot go further to the king when dead and deified. And the substantial identity thus initiated continues through subsequent stages with deities whose origins are no longer traceable.

Into the complete obeisance we saw that there enter two elements, one implying submission and the other implying liking; and into the complete form of address there enter two analogous elements. With words which seek to propitiate by abasing self or elevating the person addressed, or both, are joined words suggestive of attachment to the person addressed—wishes for his life, health, and happiness.

Professions of interest in another's well-being and good fortune are, indeed, of earlier origin than professions of subjection. Just as those huggings and kissings and pattings which indicate liking are used as complimentary observances by ungoverned or little-governed savages, who have no obeisances that signify submission, so friendly speeches precede speeches alleging subordination. Among the Snake Indians of North America, a stranger is accosted with the words, "I am much pleased, I am much rejoiced;" and in South America, among the Araucanians, whose social organization, though more advanced, has not yet been developed by militancy into the coercive type, the formality on meeting, which "occupies ten or fifteen minutes," consists of detailed inquiries about the welfare of each and his belongings, joined with elaborate felicitations and condolences.

Of course this element of the salutation persists while there grow up the acts and phrases expressing subjection. Along with servile obeisances we saw that good wishes and congratulations are addressed to a superior among negro nations, alike of the coast and the interior; and among the Fulahs and the Abyssinians inquiries concerning personal welfare and the welfare of belongings are elaborate. It is in Asia, however, where militant types of society are more highly developed, that the highest developments of these speeches occur. Beginning with such hyperbolic utterances as—"O king, live forever!" we descend to addresses between equals which, in like exaggerated ways, signify great sympathy; as among the Arabs, who indicate their anxiety by rapidly repeating, "Thank God, how are you?" for some minutes, and who, when well-bred, occasionally interrupt the subsequent conversation by again asking, "How are you?" or as among the Chinese, who thus directly assert their affection, on an ordinary visiting billet presented to the porter when making a call, "The tender and sincere friend of your lordship, and the perpetual disciple of your doctrine, presents himself to pay his duty and make his reverence even to the earth." Among Western peoples, in whose social organizations personal power has never reached so great a height, professions of liking and solicitude have

been less exaggerated; and they have decreased as freedom has increased. In the fourteenth century, in France, at the royal table, "every time the herald cried, 'The king drinks!' every one made vœux and cried, 'Long live the king!'" And, though both abroad and at home the same or an allied form of wish is still used, it recurs with nothing like the same frequency. So, too, is it with the good wishes expressed in social intercourse. Though the exclamation, "Long life to your honor!" may still be heard, it is heard among a race who, till late times under personal rule, are even now greatly controlled by their loyalty to representatives of old families; while in parts of the kingdom longer emancipated from feudal forms, and disciplined by industrialism, the ordinary expressions of interest, abridged to "How do you do?" and "Good-by," are uttered in a manner that conveys not much more feeling than is entertained. It is interesting to note that along with these phrases, very generally diffused, in which divine aid is invoked on behalf of the person saluted—as in the "May God grant you his favors" of the Arab, "God keep you well" of the Hungarian, "God protect you" of the negro; and along with those which express interest by inquiries after state of health and strength and fortune, which are also wide-spread—there are some which take their character from surrounding conditions. One is the Oriental "Peace be with you," descending from turbulent times when peace was the great *desideratum;* another is the "How do you perspire?" alleged of the Egyptians; and a still more curious one is, "How have the mosquitoes used you?" which, according to Humboldt, is the morning salutation on the Orinoco.

There remain to be noted those modifications of language, grammatical and other, which, by implication, exalt the person addressed or abase the person addressing. These have certain analogies with other elements of ceremony. We have seen that, where subjection is extreme, the ruler, if he does not keep himself invisible, must, when present, not be looked at, on pain of death; and, from the idea that it is an unpardonable liberty to gaze at an exalted person, there has arisen in some countries the usage of turning the back on a superior. Similarly the practice of kissing the ground before a reverenced person, or kissing some object belonging to him, implies that the subject person is so remote in station that he may not take the liberty of kissing even the foot or the dress. And in a kindred spirit the linguistic forms used in compliment have, in part, the trait that they avoid direct relations with the person addressed.

Special modifications of language, having, as their common result, the maintenance of a distance between superiors and inferiors, are widely diffused, and make their appearance in some comparatively early social stages. Of the superior people among the Abipones we read that "the names of men belonging to this class end in *in;* those

of the women, who also partake of these honors, in *en*. These syllables you must add even to substantives and verbs in talking with them." Again, "the Samoan language contains 'a distinct and permanent vocabulary of words which politeness requires to be made use of to superiors, or on occasions of ceremony.'" Among the Javans, "on no account is any one, of whatever rank, allowed to address his superior in the common or vernacular language of the country." And of the ancient Mexican language we are told by Gallantin that there is "a special form called Reverential, which pervades the whole language, and is found in no other. . . . this is believed to be the only one [language] in which every word uttered by the inferior reminds him of his social position."

The most general of the indirectnesses which etiquette introduces into forms of address appears to have its root in the primitive superstition respecting proper names. Conceiving that a man's name forms part of his individuality, and that possession of his name gives some power over him, savages almost everywhere are reluctant to disclose names, and consequently avoid that use of them in speech by which they are made known to hearers. Whether this is the sole cause, or whether, apart from this, utterance of a man's name is felt to be a kind of liberty taken with him, the fact is that among all races names acquire a kind of sacredness, and taking a name in vain is interdicted: especially to inferiors when addressing superiors. One curious result is that, as, in early stages, personal names are derived from objects, the names of objects have to be disused and others substituted. Among the Caffres "a wife may not publicly pronounce the *i-gama* [the name given at birth] of her husband or any of his brothers; nor may she use the interdicted word in its ordinary sense. . . . The chief's *i-gama* is withdrawn from the language of his people." Again, "the hereditary appellation of the chief of Pango-Pango [in Samoa] being now Maunga, or Mountain, that word must never be used for a hill in his presence, but a courtly term . . . substituted." And then, where there exist proper names of a developed kind, there are still kindred restrictions on the general use of them; as in Siam, where "the name of the king must not be uttered by a subject: he is always referred to by a periphrasis, such as 'the master of life,' 'the lord of the land,' 'the supreme head;'" and as in China, where "the 'old man of the house,' 'excellent honorable one,' and 'venerable great prince,' are terms used by a visitor to designate the father of his host."

Allied with avoidance of the proper name in addressing a superior, there is, as sundry of the above instances show, avoidance of the personal pronouns; which also establish with the individual addressed a relation too direct to be allowed where distance is to be maintained. In Siam, as already exemplified, when asking the king's commands the pronominal form is, as much as possible, evaded; and that this usage is general among the Siamese is shown by the remark of Père Bruguière,

that "they have personal pronouns, but rarely use them." Among the Chinese, also, this style of address descends into ordinary intercourse. "If they are not intimate friends, they never say I and You, which would be a gross incivility. But instead of saying, I am very sensible of the service you have done me, they will say, The service that the Lord or the Doctor has done for his meanest Servant, or his Scholar, has greatly affected me."

We come next to those perversions in the uses of pronouns which serve to exalt the superior and abase the inferior. "'I' and 'me' are expressed by several terms in Siamese; as (1) between a master and slave; (2) between a slave and master; (3) between a commoner and a nobleman; (4) between persons of equal rank; while there is, lastly, a form of address which is only used by the priests." Still more developed is this system among the excessively ceremonious Japanese. "In Japan all classes have an 'I' peculiar to themselves, which no other class may use; and there is one exclusively appropriated by the Mikado . . . and one confined to women. . . . There are eight pronouns of the second person peculiar to servants, pupils, and children." Though in the West the distinctions established by abusing pronominal forms have not been so much elaborated, yet they have been sufficiently marked. In Germany "in old times . . . all inferiors were spoken to in the third person singular, as 'er':" that is, an oblique form by which the inferior was not directly addressed, but merely referred to, as though in speaking to another person served to disconnect him from the speaker. And then we have the converse fact that "inferiors invariably use the third person plural in addressing their superiors:" a form which, while dignifying the superior by pluralization, increases the distance of the inferior by its relative indirectness; and a form which, beginning as a propitiation of those in power, has, like the rest, spread till it has become a general propitiation. In our own speech, lacking such misuse of pronouns as serves to humiliate, there exists only that substitution of the "you" for the "thou," which, once a complimentary exaltation, has now by diffusion through all ranks wholly lost its ceremonial meaning. Evidently it retained some ceremonial meaning at the time when the Quakers persisted in using "thou;" and that in still earlier times it was employed to ascribe dignity is inferable from the fact that during the Merovingian period in France, when the habit was but partially established, the kings ordered that they should be addressed in the plural. Whoever fails to think that calling him "you" once served to exalt the person addressed, will be aided by contemplating this perversion of speech in its primitive and more emphatic shape; as in Samoa, where they say to a chief, "Have *you two* come?" or, "Are *you two* going?"

Since they state in words what obeisances express by acts, forms of address, of course, have the same general relations to social types. The parallelisms must be briefly noted.

Speaking of the Dakotas, who are politically unorganized, and who had not even nominal chiefs till the whites began to make distinctions among them, Burton says, "Ceremony and manners, in our sense of the word, they have none;" and he instances the entrance of a Dakota into a stranger's house with a mere exclamation meaning "Well!" Bailey remarks of the Veddahs, that in addressing others "they use none of the honorifics so profusely common in Singhalese; the pronoun '*to*,' 'thou,' being alone used, whether they are addressing each other, or those whose position would entitle them to outward respect." These cases will sufficiently indicate the general fact that where there is no subordination, speeches which exalt the person spoken to and abase the person speaking do not arise. Conversely, where personal government is absolute, verbal self-humiliations and verbal exaltations of others assume exaggerated forms. Communities such as we find in Siam, where every subject is a slave of the king, are those in which the inferior calls himself dust under the feet of the superior, while ascribing to the superior transcendent powers, and where the forms of address, even between equals, avoid naming the person addressed. It is in social organizations like that of China, where there is no check on the power of the "Imperial Supreme," that the phrases of adulation and humility, first used in intercourse with rulers and afterward spreading, have elaborated to such extremes that in inquiring another's name the form is, "May I presume to ask what is your noble surname and your eminent name?" while the reply is, "The name of my cold (or poor) family is ——, and my ignoble name is ——." Or, again, if we ask where occur the most elaborate misuses of pronouns initiated by ceremony, we find them among the Japanese, over whom chronic wars long ago established a despotism which acquired divine prestige.

So, too, on comparing the Europe of past times, characterized by social structures developed by, and fitted for, perpetual fighting, with modern Europe, in which, though fighting on a large scale occurs, it is the temporary rather than the permanent form of social activity, we observe that complimentary expressions, now less used, are also less exaggerated. Nor does the contrast fail when we put side by side the modern European societies that are organized in greater degree for war, like those of the Continent, and our own society, not so well organized for war; or when we put side by side the regulative parts of our own society, which are developed by militancy, with the industrial parts. Flattering superlatives and expressions of devotion are less profuse here than they are abroad; and, much as the use of complimentary language has diminished among our ruling classes in recent times, there still remains a greater use of it than among the industrial classes—especially those of the industrial classes who have no direct relations with the ruling classes.

These connections are obviously, like previous ones, necessary. Should any one say that along with the enforced obedience which mili-

tary organization implies, and which characterizes the whole of a society framed for military action, there naturally go forms of address not expressing submission, and if, conversely, he should say that along with the active exchanging of produce, money, services, etc., freely carried on, which characterizes the life of an industrial society, there naturally go exaggerated eulogies of others and servile depreciations of self, his proposition would be manifestly absurd; and the absurdity of this hypothetical proposition serves to bring into view the truth of the actual proposition opposed to it.

EDUCATION AS A SCIENCE.[1]

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IV.

IN education there has to be encountered at every turn the play of motives. Now, the theory of motives is the theory of sensation, emotion, and will; in other words, it is the psychology of the sensitive and the active powers.

1. THE SENSES.—The pleasures, the pains, and the privations of the senses, are the earliest and the most unfailing, if not also the strongest, of motives. Besides their bearings on self-preservation, they are a principal standing dish in life's feast.

It is when the senses are looked at on the side of feeling, or as pleasure and pain, that the defectiveness of the current classification into five is most evident. For, although, in the point of view of knowledge or intellect, the five senses are the really important approaches to the mind, yet, in the view of feeling or pleasure and pain, the omission of the varied organic susceptibility leaves a wide gap in the handling of the subject. Some of our very strongest pleasures and pains grow out of the region of organic life—the digestion, circulation, respiration, muscular and nervous integrity or derangement.

In exerting influence over human beings this department of sensibility is a first resource. It can be counted on with more certainty than perhaps any other. Indeed, almost all the punishments of a purely physical kind fall within the domain of the organic sensations. What is it that makes punishment formidable, but its threatening the very vitals of the system? It is the lower degree of what, in a higher degree, takes away life.

For example, the muscular system is the seat of a mass of sensibility, pleasurable and painful: the pleasures of healthy exercise, the

[1] Continued from THE POPULAR SCIENCE MONTHLY of August, 1877.

pains of privation of exercise, and the pains of extreme fatigue. In early life, when all the muscles, as well as the senses, are fresh, the muscular organs are very largely connected both with enjoyment and with suffering. To accord full scope to the activity of the fresh organs is a gratification that may take the form of a rich reward; to refuse this scope is the infliction of misery; to compel exercise beyond the limits of the powers is still greater misery. Our penal discipline adopts the two forms of pain: in the milder treatment of the young, the irksomeness of restraint; in the severe methods with the full-grown, the torture of fatigue.

Again, the nervous system is subject to organic depression; and certain of our pains are due to this cause. The well-known state denominated "tedium" is nervous uneasiness; and is caused by undue exercise of any portion of the nervous system. In its extreme forms it is intolerable wretchedness. It is the suffering caused by penal impositions or tasks, by confinement, and by monotony of all kinds. The acute sufferings of the nervous system, as growing out of natural causes, are represented by neuralgic pains. It is in graduated artificial inflictions, operating directly on the nerves by means of electricity, that we may look for the physical punishments of the future, that are to displace floggings and muscular torture.

The interests of nourishment, as against privation of food, are necessarily bound up with a large volume of enjoyment and suffering. Starvation, deficiency and inferiority of food, are connected with depression and misery of the severest kind; inspiring the dread that most effectually stimulates human beings to work, to beg, or to steal. The obverse condition of a rich and abundant diet is in itself an almost sufficient basis of enjoyment. The play of motives between those extremes enables us to put forth an extensive sway over human conduct.

An instructive distinction may be made between privation and hunger; likewise between their opposites. Privation is the positive deficiency of nourishing material in the blood; hunger is the craving of the stomach at its usual times of being supplied, and is a local sensibility, perhaps very acute, but not marked by the profound wretchedness of inanition. There may be plenty of material to go on with, although we are suffering from stomachic hunger. Punishing, for once, by the loss of a meal out of the three or four in the day, is unimportant as regards the general vigor, yet very telling as a motive. Absolutely to diminish the available nutriment of the system is a measure of great severity; to inflict a pending hunger is not the same thing.

When we unite the acute pleasures of the palate with stomachic relish and the exhilaration of abundance of food-material in a healthy frame, we count up a large mass of pleasurable sensibility. Between the lowest demands of subsistence and the highest luxuries of affluent means there is a great range, available as an instrumentality of control in the discipline of the young. The usual regimen being something

considerably above necessaries, and yet beneath the highest pitch of indulgence, room is given to operate both by reduction and by increase of luxury, without either mischief or pampering; and, the sensibility in early years being very keen in those heads, the motive power is great. Having in view the necessities of discipline with the young, the habitual regimen in food should be pitched neither too low nor too high to permit of such variations. It is the misfortune of poverty that this means of influence is greatly wanting; the next lower depth to the delinquent child is the application of the stick.

These are the chief departments of organic sensibility that contain the motives made use of in reward and punishment. The inflictions of caning and flogging operate upon the organ of the sense of touch, yet, in reality, the effect is one to be classed among the pains of organic life, rather than among tactile sensations; it is a pain resulting from injury or violence to the tissue in the first instance, and if carried far is destructive of life. Like all physical acute pains it is a powerful deterring influence, and is doubtless the favorite punishment of every age and every race of mankind. The limitations to its use demand a rigorous handling; but the consideration of these is mixed up with motives afterward to be adverted to.

The ordinary five senses contain, in addition to their intellectual functions, many considerable sensibilities to pleasure and pain. The pleasures can be largely made use of as incentives to conduct. The pains might of course be also employed in the same way; but with the exceptions already indicated they very rarely are. We do not punish by bad odors, nor by bitter tastes. Harsh and grating sounds may be very torturing, but they are not used in discipline. The pains of sight reach the highest acuteness, but as punishment they are found only in the most barbarous codes.

Postponing a review of the principles of punishment generally, we approach the most perplexing department of motives—the higher Emotions. Few of the simple sensational effects are obtained in purity, that is, without the intermingling of emotions.

2. The Emotions.—One large department of psychology is made up of the classification, definition, and analysis of the Emotions. The applications of a complete theory of Emotion are numerous, and the systematic expansion must be such as to cope with all these applications. We here narrow the subject to what is indispensable for the play of motives in education.

First of all, it is necessary to take note of the large region of Sociability, comprising the social emotions and affections. Next is the department of Anti-social feeling—Anger, Malevolence, and Lust of Domination. Taking both the sources and the ramifications of these two leading groups, we cover perhaps three-fourths of all the sensibility that rises above the senses proper. They do not indeed exhaust the fountains of emotion, but they leave no other that can rank as of first-

class importance, except through derivation from them and the senses together.

The region of Fine Art comprises a large compass of pleasurable feeling, with corresponding susceptibilities to pain; some of this is sensation proper, being the pleasures of the two higher senses; some is due to associations with the interests of all the senses (Beauty of Utility); a certain portion may be called Intellectual, the perception of unity in variety; while the still largest share appears to be derived from the two great sources above described.

The Intellect generally is a source of various gratifications and also of sufferings that are necessarily mixed up with our intellectual education. Both the delights of attained knowledge and the pains of intellectual labor have to be carefully counted with by every instructor.

The pleasures of Action or Activity are a class greatly pressed into the educational service, and therefore demand special consideration.

The names Self-Esteem, Pride, Vanity, Love of Praise, express powerful sentiments, whose analysis is attended with much subtilty. They are largely appealed to by every one that has to exercise control over human beings. To gratify them is to impart copious pleasure, to thwart or wound them is to inflict corresponding pain.

Mention has not yet been made of one genus of emotion, formidable as a source of pain, and as a motive to activity, namely, Fear or Terror. Only in the shape of reaction or relief is it a source of pleasure. The skillful management of this sensibility has much to do with the efficient control of all sentient creatures, and still more with the saving of gratuitous misery.

Our rapid review of these various sources of emotion, together with others of a minor kind, proposes to deal once for all, and in the best manner, with the various educational questions that turn upon the operation of motives. We shall have to remark upon prevailing exaggerations on some heads and the insufficient stress laid on others; and shall endeavor to unfold in just proportions the entire compass of our emotional susceptibilities available for the purposes of the teacher.

3. The Emotion of Terror.—The state of mind named Terror or Fear is described shortly as a state of extreme misery and depression, prostrating the activity and causing exaggeration of ideas in whatever is related to it. It is an addition to pain pure and simple—the pain of a present infliction. It is roused by the foretaste or prospect of evil, especially if that is great in amount, and still more if it is of uncertain nature.

As far as education is concerned, terror is an incident of the infliction of punishment. We may work by the motive of evil without producing the state of terror, as when the evil is slight and well defined; a small understood privation, a moderate dose of irksomeness, may be salutary and preventive, without any admixture of the quakings and misery of fear. A severe infliction in prospect will in-

duce fear; the more so that the subject does not know how severe it is to be.

In the higher moral education, the management of the passion of fear is of the greatest consequence. The evils of operating by means of it are so great that it should be reserved for the last resort. The waste of energy and the scattering of the thoughts are ruinous to the interests of mental progress. The one certain result is to paralyze and arrest action, or else to concentrate force in some single point, at the cost of general debility. The tyrant, working by terror, disarms rebelliousness, but fails to procure energetic service, while engendering hatred and preparing for his overthrow.

The worst of all modes and instruments of discipline is the employment of spiritual, ghostly, or superstitious terrors. Unless it were to scourge and thwart the greatest of criminals—the disturbers of the peace of mankind—hardly anything justifies the terrors of superstition. On a small scale, we know what it is to frighten children with ghosts; on a larger scale is the influence of religions dealing almost exclusively in the fear of another life.

Like the other gross passions, terror admits of being refined upon and toned down, till it becomes simply a gentle stimulation; and the reaction more than makes up for the misery. The greatest efforts in this direction are found in the artistic handling of fear, as in the sympathetic fears of tragedy, and in the passing terrors of a well-constructed plot. In the moral bearings of the emotions, its refined modes are shown in the fear of giving pain or offense to one that we love, respect, or venerate. There may be a considerable degree of the depressing element even in this situation; yet the effect is altogether wholesome and ennobling. All superiors should aspire to be feared in this manner.

Timidity, or susceptibility to fear, is one of the noted differences of character; and this difference is to be taken into account in discipline. The absence of general vigor, bodily and mental, is marked by timidity; and the state may also be the result of long bad usage, and of perverted views of the world. In the way of culture, or of high exertion in any form, little is to be expected from thoroughly timid natures; they can be easily governed, so far as concerns sins of commission, but their omissions are not equally remediable.

The conquest of superstitious fears is one of the grandest objects of education taken in its widest compass. It cannot be accomplished by any direct inculcation; it is one of the incidental and most beneficial results of the exact study of Nature—in other words, science.

4. The Social Motives.—This is perhaps the most extensive and the least involved of all the emotional influences at work in education.

The pleasures of love, affection, mutual regard, sympathy, or sociability, make up the foremost satisfaction of human life; and as such are a standing object of desire, pursuit, and fruition. Sociability is a

wholly distinct fact from the prime supports of existence and the pleasures of the five senses, and is not, in my opinion, resolvable into those, however deeply we may analyze it, or however far back we may trace the historical evolution of the mind. Nevertheless, as the supports of life, and the pure sense agreeables and exemptions, come to us in great part through the medium of fellow-beings, the value of the social regards receives from this cause an enormous augmentation, and, in the total, counts for one paramount object of human solicitude. It would appear strange if this motive could ever be overlooked by the educator, or by any one; yet there are theories and methods that treat it as of inferior account.

The vast aggregate of social feeling is made up of the intenser elements of sexual and parental love, and the select attachments in the way of friendship, together with the more diffused sentiments toward the masses of human beings. The motive power of the feelings in education may be well exemplified in the intense examples; we can see in these both the merits and defects of the social stimulus. The "Phædrus" of Plato is a remarkable ideal picture of the study of philosophy prompted by Eros, in the Grecian form of attachment. The ordinary love of the sexes, in our time, does not furnish many instances of the mutual striving after high culture; it may be left out of account in the theory of early education. We frequently find mothers applying to studies that they feel no personal attraction for, in order to assist in the progress of their children. This is much better than nothing; a secondary end may be the initiation and discovery of a taste that at last is self-subsisting.

The intense emotions, from the very fact of their intensity, are unsuited to the promptings of severe culture. The hardest studious work, the laying of foundations, should be over, before the flame of sexual and parental passion is kindled; when this is at its height the intellectual power is in abeyance, or else diverted from its regular course. The mutual influence of two lovers is not educative for want of the proper conditions. No doubt considerable efforts are inspired; but there is seldom sufficient elevation of view on the one side, or sufficient adaptability on the other, to make the mutual influence what Plato and the romancists conceive as possible. By very different and inferior compliances on both sides, the feeling may be kept alive; if more is wanted, it dies away.

The favorable conjunction for study and mental culture in general is friendship between two, or a small number, each naturally smitten with the love of knowledge for its own sake, and basing their attachment on that circumstance. A certain amount of mutual liking in other respects perfects the relationship; but the overpowering sensuous regards of the Platonic couple do not furnish the requisite soil for high culture. As a matter of fact, those attachments, as they existed in Greece, prompted to signal instances of self-devotion in the form of

surrendering worldly goods and life itself; and this is the highest fruit that they have yielded in later times.

The remaining aspect of sociability—the influence of the general multitude—holds out the most powerful and permanent motive to conduct, and is largely felt in education. In the presence of an assembly the individual is roused, agitated, swayed; the thrill of numbers is electric; in whatever direction the influence tends, it is almost irresistible. Any effort made in the sight of a host is totally altered in character; and all impressions are very much deepened.

Having in view this ascendency of numbers, we can make a step toward computing the efficacy of class-teaching, public schools, and institutions where great multitudes are brought together. The power exercised is of a mixed character and the several elements admit of being singled out. The social motive, in its pure form of gregarious attraction and mutual sympathy, does not stand alone. Supposing it did, the effect would be to supply a strong stimulus in favor of everything that was supported by common consent; the individual would be urged to attain the level of the mass. The drill of a regiment of soldiers corresponds very nearly to this situation; every man is under the eye of the whole, and aspires to be what the rest are and not much, if anything, beyond; the sympathetic coöperation of the mass, guides, stimulates, and rewards the exertion of the individual. Even if it were the destination of a soldier to act as an isolated individual, still his education would be most efficaciously conducted in the mass system, being finished off by a certain amount of separate exercise to prepare for the detached or independent position.

In every kind of education in classes, the social feeling, in the pure form now assumed, is frequently operative, and the results are as stated. The tendency is to secure a certain approved level of attainment: those that are disinclined of themselves to work up to that level are pushed on by the influence of the mass. If there were no other strong passions called out in society, the general result would be a kind of communism or socialism characterized by mediocrity and dead level; everything correct up to a certain point, but no individual superiority or distinction.

The influence of society as the dispenser of collective good and evil things, in addition to its operation in the affections and sympathies, is necessarily all-powerful in every direction. If this stimulus were always to coincide with high mental culture, the effect would be something that the imagination hardly dares to shadow forth. It is, however, a power that may be propitiated by many different means, including shams and evasions, and the bearing upon culture is only occasional. Nevertheless, the social rewards have often served to foster the highest genius—the oratory of Demosthenes, and the poetry of Horace and Virgil—a form of genius notoriously allied with toil and perseverance of the most arduous kind. The same influence, working by disappro-

bation and approbation combined, is, as I contend, the principal generating source of the ordinary moral sentiments of mankind, and the inspiration of exceptional virtues.

5. The Anti-social and Malign Emotions.—The emotions of Anger, Hatred, Antipathy, Rivalry, Contumely, have reference to other beings, no less than Love or Affection, but in an opposite way. In spite of the painful incidents in their manifestation—the offense in the first instance, and the dangers of reprisal—they are a source of immediate pleasure, often not inferior, and sometimes superior, in amount to the pleasures of amity and gregarious coöperation. In numerous instances people are willing to forego social and sympathetic delights to indulge in the pleasures of malignity.

In the work of discipline the present class of emotions occasions much solicitude. They can in certain ways be turned to good account; but, for the larger part, the business of the educator and the moralist is to counterwork them as being fraught with unalloyed evil.

Being a fitful or explosive passion, anger should, as far as possible, be checked or controlled in the young; but there are no adequate means, short of the very highest influence of the parent or teacher. The restraint induced by the presence of a dread superior at the time does not sink deep enough to make a habit; opportunities are sought and found to vent the passion with safety. The cultivation of the sympathies and affections is what alone copes with angry passion, both as a disturber of equanimity and as the prompter of wrong. The obverse of ill-temper is the disposition that thinks less of harm done to self and more of harm done to other people; and, if we can do anything to foster this disposition, we reduce the sphere of malignant passion. The collateral incentives to suppress angry passion include, besides the universal remedy of disaprobation, an appeal to the sense of personal dignity and to the baneful consequences of passionate outbursts.

The worst form of malignant feeling is cold and deliberate delight in cruelty; all too frequent, especially in the young. The torturing of animals, of weak and defenseless human beings, is the spontaneous outflow of the perennial fountain of malevolence. This has to be checked, if need be, at the expense of considerable severity. The inflictions practised on those that are able to recriminate, generally find their own remedy; and the discipline of consequences is as effectual as any. By having to fight our equals, we are taught to regulate our wrathful and cruel propensities.

The intense pleasure of victory contains the sweetness of malevolence, heightened by some other ingredients. The prostration and destruction of an enemy or a rival is, no doubt, the primary situation where malevolent impulses had their rise; and it continues to be, perhaps, the very strongest stimulant of the human energies. Notwithstanding its several drawbacks, we are obliged to give it a place among

motives to study and mental advancement. In the fight and struggle of party contests the pleasure of victory enters in full flavor; and in the competitions at school the same motive is at work.

The social problem of restraining individuals in their selfish grasping of good things—the mere agreeables and exemptions of the senses—is rendered still more intractable by the craving for the smack of malevolent gratification. Total repression has been found impossible; and ingenuity has devised a number of outlets that are more or less compatible with the sacredness of mutual rights.

One chief outlet for the malevolent impulses is the avenging of wrong, whether private or public. A convicted wrong-doer is punished by the law, and the indignation roused by the crime turns to gratification at the punishment. In the theory of penal retribution some allowance is claimed for the vindictive satisfaction of the public. To think only of the prevention of crime, and the reformation of criminals, and suppressing all resentful feeling, is a severe and ascetic view, beyond human nature as at present constituted. The privacy of the punishments of criminals, in our modern system, is intended to keep the indulgence within bounds.

A wide ideal scope is given to our resentful pleasures in history and in romance; we are gratified by the retribution inflicted upon the authors of wrong. Narratives of evil-doers and of their punishment are level to the meanest capacity; this is the sort of history that suits the imagination even of children.

The highest refinement of the malevolent gratification I take to be the creation called the ludicrous and the comic. There is a laugh of vindictiveness, hatred, and derision, which carries the sentiment as far as it can be carried without blows. But there is also the laugh expressed by playfulness and humor, in which the malignant feeling seems almost on the point of disappearing in favor of the amicable sentiment. It is of some importance to understand that in play, fun, and humor, there is a delicate counterpoise of opposing sentiments, an attempt to make the most of both worlds—love and anger. The great masterpieces of humor in literature, the amenities of every-day society, the innocent joyousness of laughter—all attest the success of the hazardous combination. Nothing could better show the intensity of the primitive charm of malevolence than the unction that survives after it is attenuated to the condition of innocent mirthfulness. When the real exercise of the destructive propensity is not to be had, creatures endowed with emotions still relish the fictitious forms. This is seen remarkably in the amicable "play" of puppies and kittens. Not being endowed with much compass of the caressing acts, they show their love by snarling and sham biting; in which, through their fortunate self-restraint, they seem to enjoy a double pleasure. In the play of children there is the same employment of the forms of destructive malevolence, and, so long as it is happily balanced, the effect is highly piquant. By

submitting in turn to be victimized, a party of children can secure, at a moderate cost to each, the zest of the malevolent feeling; and this I take to be the quintessence of play.

The use of this close analysis is to fix attention upon the precarious tenure of all these enjoyments, and to render a precise reason for the well-known fact that play or fun is always on the eve of becoming earnest; in other words, the destructive or malevolent element is in constant danger of breaking loose from its checks, and of passing from fictitious to actual inflictions. The play of the canine and the feline kind often degenerates in this fashion; and in childish and youthful amusements it is a perpetual rock ahead.

It is no less dangerous to indulge people in too much ideal gratification of the vindictive sentiments. Tales of revenge against enemies are too apt to cultivate the malevolent propensity. Children, it is true, take up this theme with wonderful alacrity; nevertheless it is a species of pampering supplied to the worst emotions instead of the best.

One other bearing of irascibility on education needs to be touched. When disapproval is heightened with anger, the dread inspired is much greater. The victim anticipates a more severe infliction when the angry passion has been roused; hence the supposition is natural that anger is an aid to discipline. This, however, needs qualifying. Of course, any increase of severity has a known deterrent effect, with whatever drawbacks may attend the excess. But anger is fitful; and, therefore, its coöperation mars discipline by want of measure and want of consistency; when the fit has passed, the mind often relapses into a mood unfavorable to a proper amount of repression.

The function of anger in discipline may be something very grand, provided the passion can be controlled. There is a fine attitude of indignation against wrong that may be assumed with the best effect. It supposes the most perfect self-command, and is no more excited than seems befitting the occasion. Mankind would not be contented to see the bench of justice occupied by a calculating machine that turned up a penalty of five pounds, or a month's imprisonment, when certain facts were dropped in at the hopper. A regulated expression of angry feeling is a force in itself. Neither containing fitfulness, nor conducting to excess of infliction, it is the awe-inspiring personation of justice, and is often sufficient to quell insubordination.

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SEA-SIDE STUDIES.

By Professor SANBORN TENNEY.

AMONG the thousands who visit the sea-shore in summer, there are many who, although not naturalists, are more or less interested in the various marine forms which there abound, and perhaps a brief notice of some of these forms will be acceptable to those who have not made a special study of life as it is revealed in the sea.

If an observer be on a rocky shore he will not fail to become interested in the "sea-anemones," those "flowers of the sea" which at first view appear to be on the border-land between plants and animals, so that one hardly knows whether to refer them to the vegetable or to the animal kingdom.

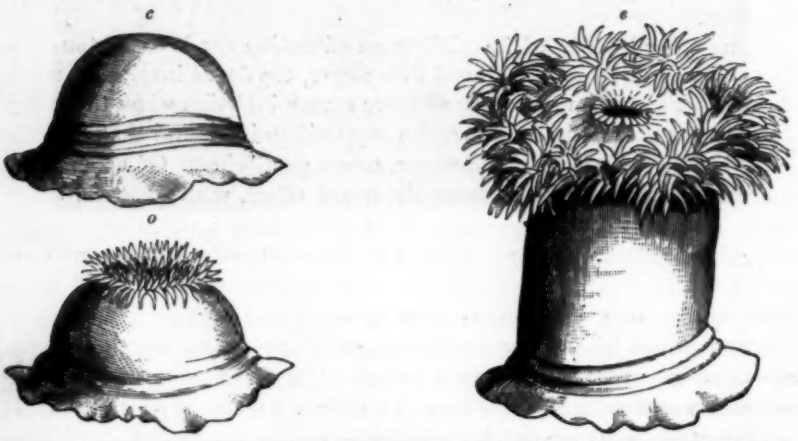


Fig. 1.—Actinia, or Sea-Anemone (*Metridium marginatum*, Milne-Edwards): *c*, closed; *o*, opening; *e*, expanded.

Although some sea-anemones live in the sand (Fig. 2), the home of the ordinary kinds is the pools and caverns among the rocks; here we may find and study them when the tide is out. Groups, sometimes in thousands, and standing so closely together that they cover the whole interior of the rocky cavern or grotto, are not uncommon. Some are expanded to their fullest extent, like a full-blown flower; others are only partly open; others are just opening; and others still are closed as tightly as the bud of a flower, which they more or less resemble.

Various are the colors which they exhibit, from pale or nearly white to the richest hues of pink, rose, red, and purple.

In the centre of the top there is an opening or mouth, which leads directly into a central sac or stomach, and around the mouth are rows of long and delicate hollow appendages, which the animal moves freely

to and fro in the water, and with which it can bring the food to its mouth. As soon as a snail or other small animal falls among the fringes, these close around it and move it toward the mouth, where it is soon swallowed, the soft parts digested and the hard parts excluded. By means of its broad base or "foot," the sea-anemone attaches itself

FIG. 2.—ACTINIÆ OR SEA-ANEMONES WHICH LIVE IN THE SAND AND ARE OFTEN UNATTACHED. 1. *Peachia hastata*, Gosse.—2. *Edwardsia callimorphia*, Gosse.—*Halocampa chrysanthellum*, Gosse—the last mostly buried in the sand.

firmly to the rock or shell on which it rests, and seldom moves from the spot which it has chosen, although it can effect locomotion by means of its "foot." By this it clings so firmly to the rock that it sometimes suffers itself to be torn in two rather than let go its hold.

The main cavity of the body in the sea-anemones is divided by septa or partitions, which run from the top to the bottom, and from the outer wall to the stomach. These partitions or septa are in pairs, and the number is some multiple of six. By what principle of selection this constant number was introduced we may be curious enough to inquire, but we must not expect to receive at once a perfectly satisfactory answer.

FIG. 3.—CROSS-SECTION OF A POLYP, OR SEA-ANEMONE, SHOWING THE SEPTA.

The partitions above mentioned are the infolding of the body-wall of the animal, and are essentially the same as the wall itself. Toward the top of each partition there is a hole, permitting free passage for the water to flow from one chamber to another.

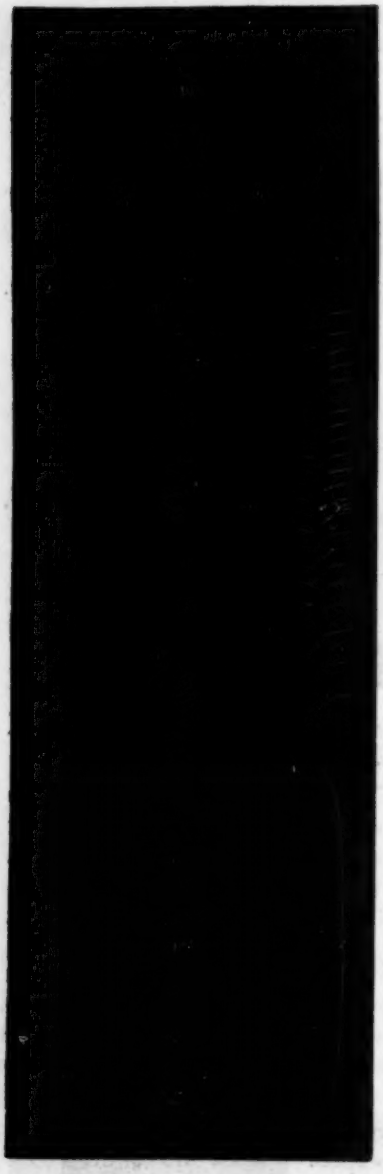


FIG. 4.—CNIDÆ, OR LASSO-CELLS, SOME WITH THE LASSO COILED WITHIN, AND OTHERS WITH THE LASSO EXTENDED; ONLY A PART OF THE LENGTH IS SHOWN. 1. Lasso-cells of an Actinia, with the lasso coiled within—its actual length $\frac{1}{50}$ of an inch. 2. The same as 1, with the lasso extended. 3 and 4 are alike—the former with the lasso coiled within, and the latter with the lasso extended. 6, 7, 8, 9, 10, a lasso-cell in different stages of development.

On various parts of the sea-anemones, and of all other polyps, especially on their tentacles or fringes, there are very remarkable objects called cnidæ, or lasso-cells, like those on jelly-fishes, each cell being less than one two-hundredths of an inch in length. In each there is a long, slender, coiled, and wonderfully-constructed thread, which can be instantly darted forth, paralyzing any little animal which it strikes; and thus the hungry polyp secures its food.

On the vertical partitions above mentioned the eggs are borne. These pass out into the water through the mouth. The newly-hatched anemone is oval in form, and swims freely about in the water by means of exceedingly delicate fringes called vibratile cilia. After a time it quits this roving life, attaches itself to the surface of the rocks, and grows into the form and size of the parent.

Sea-anemones have no proper nervous system. The sense of touch is distributed throughout the whole animal. It will, therefore, appear as a remarkable statement that some kinds have quite definitely-formed eyes. These are seen in some tropical species just outside of the tentacles, and according to Dana each of these eyes has a crystalline lens and an optic nerve!

Sea-anemones readily reproduce lost parts. If one is quickly torn from a rock, parts of the foot remain attached to the rock, and in many cases each portion thus left will become a perfect sea-anemone!

Sea-anemones vary greatly in size. Some species are only a frac-

tion of an inch in diameter. Our most common kinds are from one to two inches, and expand from two to four inches. Some of the tropical kinds are a foot in diameter.

FIG. 5.—CLUSTER OF CORAL-POLYPS (*Asteroides calycularis*, Milne-Edwards)—in various stages of expansion.

FIG. 6.—DEAD CORAL (*Asteroides calycularis*, Milne-Edwards.)—The coral of Fig. 5.

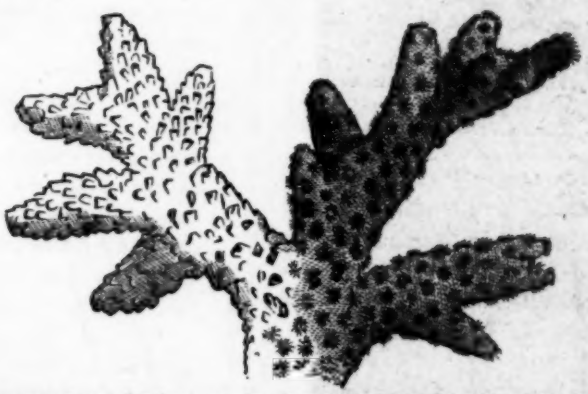


FIG. 7.—MADREPORE CORAL (*Madrepora aspera*, Dana). Right-hand branches alive; the left, dead.

The sea-anemones, whether in their natural home or in the aquarium, are exceedingly interesting objects; and in the latter place we can study them to the best advantage. Carefully remove a dozen of them

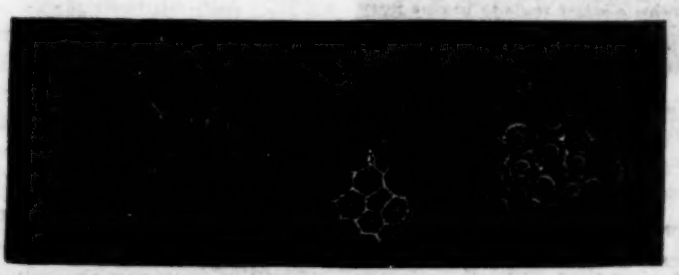


FIG. 8.—DANA'S ASTRANGIA (*Astrangia Danæ*, Agassiz): *c*, a growing cluster; *a*, a single polyp enlarged; *b*, the dead coral.

from the rocks; lay them in your basket, with plenty of wet sea-weeds; break from the rock some fragments with the sea-weeds still growing upon them; on your return to your studio put the whole into your aquarium, well supplied with pure sea-water. At first, the sea-anemones will appear like so many mere lumps of soft flesh, without definite form. But leave them there for a night; and, when you look again, you will find each one has established itself, and has expanded into a thing of beauty.

Those polyps which form the beautiful clusters of coral that adorn our mantels and museums, and which build up the vast coral-reefs and islands, differ in only one important respect from the sea-anemones.

FIG. 9.—*Sarsia* (*Coryne*) *mirabilis* (Agassiz). Cluster of Hydroids growing on sea-weeds.

FIG. 10.—Single individual of Fig. 9 enlarged, showing *a b* just ready to become free jelly-fishes or Medusæ; Fig. 11, *c*, young bud.

FIG. 11.—*Sarsia* (*Coryne*) *mirabilis* (Agassiz). Adult, Massachusetts Bay.

The sea-anemones are wholly soft; they secrete no skeleton, or only the merest particles of hard matter. On the other hand, the coral-producing polyps secrete a stony skeleton. The old notion that coral is something built by an insect is entirely erroneous. The coral-producing animal is in no sense an insect, nor does it toil to build the clusters and reefs of coral which it forms. The coral-polyp lives and eats, and the getting of its food is the only labor of its life.

Coral assumes a variety of shapes, imitating almost all forms of vegetation on the land.

Most of the coral-producing polyps are confined to the tropical parts of the ocean. A few kinds live in temperate waters. Dana's *Astrangia* lives and flourishes in Long Island Sound, where it occurs in little clusters upon stones and shells.

The visitor to the sea-shore will hardly fail to find among the growing sea-weeds little plant-like clusters like the one represented by Fig. 9. This is a cluster of hydroids, and its life-history is very interesting. The beginner may well be pardoned if he mistake these little clusters for plants, but they are indeed animals. From each little branch there arise buds (Fig. 10), which enlarge, till at length they become detached, float away, and grow into the beautiful jelly-fishes known as *Sarsia* or *Coryne;* it has been called by both names, the latter name meaning a club, and the former coming from Sars, the distinguished Norwegian naturalist, who was one of their earliest investigators.

Other hydroids, called *Campanularians*, will be found among sea-weeds. Here the minute jelly-fishes are formed in little bell-shaped organs (Fig. 12). At length they drop out into the water and become free jelly-fishes similar to *Tiaropsis* (Fig. 14).

FIG. 12.—CAMPANULARIAN (*Obelia commisuralis*, McCready). The hydro-medusæ in the cups drop out and become free Medusæ, or jelly-fishes, similar to Fig. 14.

FIG. 14.—CAMPANULARIAN (*Tiaropsis diademata*, Agassiz).

FIG. 13.—*Tubularia Couthouyi* (Agassiz). *m*, Medusæ; *ct*, coronal tentacles; *p*, proboscis.

The visitor will find other hydroids, which appear like miniature trees with all their foliage crowded to the top, and from beneath which there hang bunches, as it were, of grapes or other fruit. Such is *Tu-*

bularia, and the little fruit-like clusters are persistent jelly-fishes which develop and remain just beneath the row of tentacles (Fig. 13), instead of becoming free jelly-fishes as in *Sarsia* and in *Campanularia*.

In the Gulf of Mexico are communities of hydroids so organized that they seem to constitute but one animal. Such is the well-known "Portugese man-of-war" (Fig. 15). This community consists of an elegantly-crested air-sac floating upon the water, and giving off numerous long and variously-constructed appendages. According to Agassiz, the different parts are so many different kinds of members in the community, and fulfill widely-different offices, some catching and eating food for the whole, others producing buds, others being the locomotive or swimming members, and having tentacles that in some cases are twenty or thirty feet long. The air-sac itself is only a few inches in length.

FIG. 15.—PORTUGUESE MAN-OF-WAR (*Physalia arethusa*).

But the most common jelly-fishes are those which are more or less disk-shaped, and hence are called the *Discophoræ*. The "sunfish" is one of these. This name, we hasten to say, is rather indefinite when used without modification, for it is not only applied to a jelly-fish, but it is also given to our fresh-water bream, and to one of the large marine fishes—*orthogoriscus*. The "sunfish" of which we now speak attains a diameter of six to twelve inches (Fig. 19). In the early spring it may be seen in large schools near the surface of the water, and at this time is only a small fraction of an inch in diameter. It becomes full-grown by the middle of summer, and great numbers may then be seen swimming slowly by a sort of motion that may be likened to that of partly shutting and opening an umbrella. The motion is indeed effected by the contraction and expansion of the whole umbrella-like disk.

In the study of the sunfish (*Aurelia*) we are able to see plainly the prominent differences between jelly-fishes as a group and polyps as a group.

The natural attitude of the latter is with the mouth upward, or at least not turned downward, and the body is divided into vertical chambers, by vertical partitions, and the substance of the animal is flesh-like. On the other hand, the typical adult jelly-fishes have their mouth on the under surface, or at least not turned upward, their sub-

stance is jelly-like, and their body is traversed by tubes which radiate from the centre to the circumference.

The sunfish, and all the disk-shaped jelly-fishes especially, are remarkable for their stinging properties. When they come in contact

FIG. 16.—SCYPHISTOMA of *Aurelia flavidula* (Per. & LeS). Magnified about seven diameters.

FIG. 17.—STROBILA of *Aurelia flavidula* (Per. & LeS). Magnified about seven diameters.

FIG. 18.—STROBILA of *Aurelia flavidula* (Per. & LeS). Magnified fifteen diameters.

with the flesh of the bather, they cause a stinging sensation, similar to that produced by nettles. This is why they are called sea-nettles, and why in scientific books they are called *Acalephæ*.

Toward the close of summer the sunfish lays numerous eggs, and in the autumn it perishes. The eggs hatch into little oval bodies,

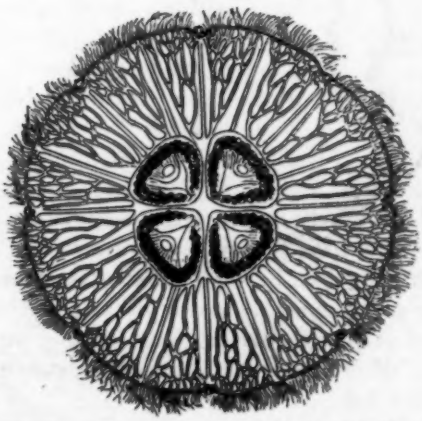


FIG. 19.—SUNFISH (*Aurelia flavidula*, Per. & LeS). Offspring of Figs. 16-18.

which swim freely about by means of minute hair-like appendages. After a time each one of these free-moving bodies attaches itself to a rock, shell, or sea-weed, and takes the form of a plant, and is then called *scyphistoma* (Fig. 16). As this goes on growing, it soon begins to divide into segments by horizontal constructions. By this process our little scyphistoma becomes a *strobila* (Figs. 17, 18). By continued

growth the segments become more and more marked, more and more separated, and at length the uppermost one drops off, then the next one drops, then the next, and so each in its turn breaks away from the parent stalk; and as each breaks away it assumes the natural attitude, mouth downward, and floats away to lead its independent life as a genuine sunfish. Here we have a good illustration of that strange mode of reproduction called "partheno-genesis" or "alternations of generations"—that is, the egg hatches into the *planula*, which soon becomes a *scyphistoma;* that little plant-like body becomes a *strobila*, and this breaks into segments, each of which becomes a perfect jelly-fish, which produces the eggs.

The species of jelly-fishes of the disk, or partially hemispherical form, are very numerous and varied in details of structure, in form, and in size. Some have the appendages around the mouth and the margin greatly prolonged as in Fig. 20. A few kinds attain a diam-

FIG. 20.—JELLY-FISH (*Pelagia cyanella*, Agassiz).

FIG. 21.—PLEUROBRACHIA (*P. rhododactyla*, Agassiz).

meter of two or three feet; and these largest kinds have in some cases tentacles a hundred feet long.

One of the most beautiful of all the jelly-fishes is the rose-colored *idyia*. It is often seen near the shore, and is so transparent that it reveals almost its whole structure as it floats in the water. It is

sometimes so abundant that it gives a rosy hue to considerable areas of the sea. It attains a length of three or four inches, and in form is not very unlike an elongated melon with one end cut square off.

Closely related to idyia is *pleurobrachia*, one of the commonest of the "comb-bearers," or *Ctenophoræ*, on the northern coast of the United States. This jelly-fish, less than an inch in length, like all other *Ctenophoræ*, has eight rows of locomotive fringes dividing the surface of the body into regions as the ribs divide the surface of a musk-melon. Besides these eight rows of fringes, or locomotive organs, it has two most extraordinary tentacles; and no form of expansion, or contraction, or curve, or spiral, can be conceived of, which these wonderfully constructed tentacles do not assume as this transparent jelly-fish moves freely through the water.

If the visitor to the sea-shore will go down among the big rocks left bare by the retiring tide, and will lift up the long sea-weeds which hang from their sides, he will find the curious "starfishes," or "sea-stars," in some cases in great profusion, and clinging to the surface of the rock so firmly that they often leave some of their locomotive suckers attached when too quickly lifted from their places.

The starfishes have the body so gradually merging into the arms

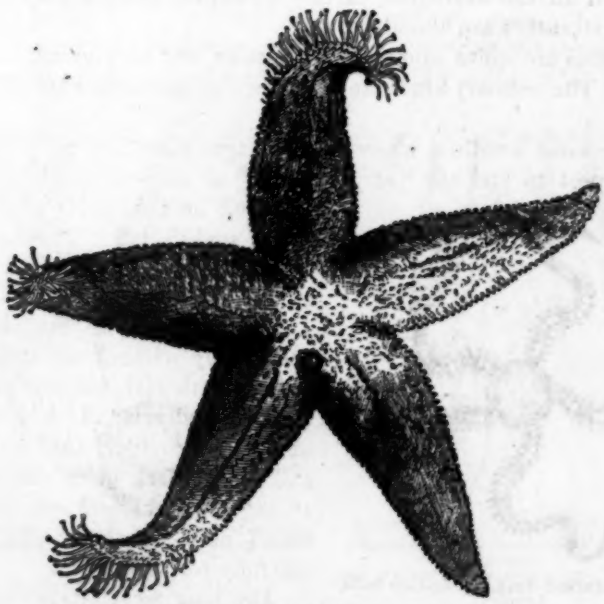


FIG. 22.—STARFISH (*Asteracanthion*).

or rays that one can hardly tell where the body ends and the arms begin; and this enables one to readily distinguish them at sight from the "serpent-stars," which are sometimes called star-fishes, and of

which we will presently speak. The mouth is in the centre of the under side, and beneath each ray there are a large number of locomotive suckers. An eye is situated at the end of each ray; and on the back, near the junction of two arms, is a sort of water-filter called the madreporic body.

As in all similar cases, the dried specimens give us only a partial idea of the real starfishes, and those who have studied these animals in museums only have little idea of the readiness with which they make their way along the vertical and overhanging surfaces of rocks, and into holes and narrow fissures.

Starfishes are very voracious, and feed mainly on mollusks. They are exceedingly destructive to oysters in many places, and thus come in direct competition with man for the possession of this delicious bivalve. Instead of swallowing their food as other animals do, they turn the stomach out of the mouth and over the animal which they wish to devour!

Starfishes have a wonderful power of reproducing lost parts. If an arm is bitten off by a hungry fish, another grows in its place; and cases are known where all the arms but one have been detached, and the remaining arm and central portion of the body have lived on and reproduced all the destroyed parts. Examples of this may be seen wherever starfishes are abundant.

Starfishes are quite numerous in species, and vary greatly in form and size. The ordinary kinds are only three or four inches across, others a foot.

In the same localities where we find true starfishes, we may confidently expect to find the "serpent-stars" or serpent-tailed starfishes, so called because their arms taper like a snake's tail. They are also called "brittle-stars," because they break so easily.

FIG. 23.—SERPENT-STAR (*Ophiopholis bellis*, Lyman).

Many visitors to the sea-shore come away without seeing a single living brittle-star, because the curious echinoderms which bear this name hide under the sea-weeds, and in the dark holes and crevices among the rocks, and are, therefore, found only by those who search carefully for them.

The long, gently-tapering arms, starting out abruptly from a well-defined disk, make the form of serpent-stars very distinct from that of the *Asteroidæ* or genuine sea-stars, already noticed. And, unlike the true starfishes, they have no interambulacral plates, but a series of large plates envelops the whole of each ray or arm, meeting in a

ridge along its under surface. They have no genuine locomotive suckers like starfishes, but instead they have numerous tuberculated organs which pass out through holes in the sides of the arms. Their madreporic body is in one of the circular plates on the under side of the disk.

Allusion is made above to the brittleness of the serpent-stars. This sort of brittleness is not confined exclusively to these echinoderms: at least one species of starfish exhibits the same property. The lamented Prof. Edward Forbes tells a story of his experience with a starfish known as *Luidia*, which shows that it equals any serpent-star in brittleness. The professor went dredging for the *Luidia*. He brought up a fine specimen and laid it on one of the benches in the boat, and went on with his dredging. When he was ready to go home he found his *Luidia* in fragments. It had gone to pieces of its own accord—probably by contraction. Much disappointed by the loss of so desirable a specimen, he determined to take great precautions when he should capture another *Luidia*, that he might not again have to put up with pieces only. So, next time, he took the precaution to carry a bucketful of pure fresh-water, intending to plunge the *Luidia* into it, thus paralyzing and saving it before it should have time to break itself in pieces. Pulling up the dredge and seeing that he had a fine specimen,

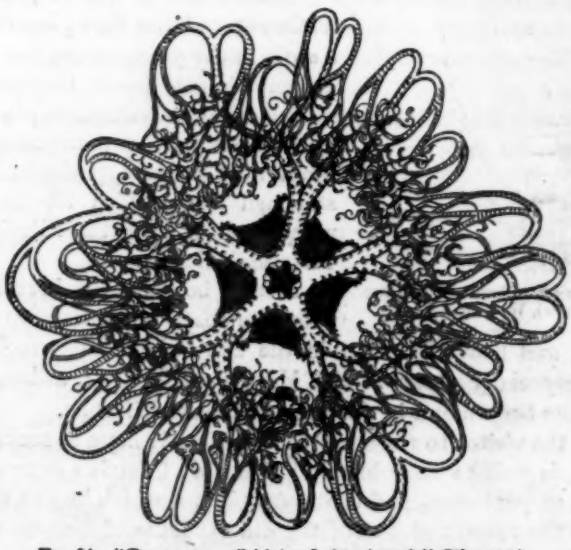


FIG. 24.—"BASKET-FISH" (*Astrophyton Agassizii*, Stimpson).

he let down his bucket of fresh-water so that its top was near the surface of the sea, intending, as soon as the dredge should reach the surface, to overturn it into the bucket; but, just when he would lift the dredge from the sea, the *Luidia*, as if apprehending the situation, went to pieces, and these began to disappear through the meshes;

and, as one of the last was vanishing, the professor imagined that the eye looked back at him with a peculiar and suggestive wink of derision!

The most remarkable representative of the serpent-stars or *Ophiurans*, as they are called in scientific books, is the "basket-fish," or *Astrophyton*. The ordinary kinds, as we have seen, have the arms simple; but one genus has the arms extensively branched (Fig. 24). This kind inhabits the deeper waters, and will not be readily obtained except through the aid of dredgers or fishermen, who sometimes bring it up attached to their lines. It attains a diameter of ten or more inches, and the arms go on dividing and subdividing until the divisions are said to number more than 80,000!

If we imagine the *Astrophyton* with its mouth turned upward, and its arms brought near together, and the ab-oral region furnished with a long, jointed, and flexible stem, we shall have a form not very unlike the *Pentacrinus caput-medusæ* (Fig. 25), of the West Indies, one of the few survivors of the order of *Crinoids* that was represented by a great number of species in the palæozoic ages of the earth's history.

FIG. 25.—CRINOID (*Pentacrinus caput-medusæ*), West Indies.

Some kinds of crinoids, as the rosy feather-star of the European coast, have a stem in the young state, but at length become detached and live as free crinoids. They thus illustrate, in their embryonic stage, the permanent form of the living stemmed species and of those stemmed forms which fill the rocks in many regions, from the Silurian to the Triassic, inclusive.

It may be remarked here that in no place are fossil crinoids more abundant or varied, and beautiful, than in the sub-carboniferous rocks of this country, especially those in the Mississippi Valley; although larger species have been found in the Triassic rocks of Europe.

While the visitor to the sea-shore may hardly hope to secure a living crinoid, it is well to bear in mind that this form is a near ally of the starfishes, serpent-stars, and the *Astrophyton*, which he can secure.

It was the remark of one of the old students of Nature that there was nothing on the land that has not its counterpart in the sea. And, if we recall some of the names that have been given to marine forms, we shall see how men have been struck with the resemblances between animals of the land and those of the water. Among fishes we have "sea-vampires," "sea-eagles," "sea-wolves," "sea-hounds," "sea-robins," "sea-swallows," "sea-horses," etc. Among mammals we have "sea-elephants," "sea-lions," "sea-bears," "sea-cows," etc.

Among the lower forms we find sea-hedgehogs, that is, "sea-urchins," and "sea-cucumbers." It is of these I would now briefly speak, as they are among the interesting things which the visitor to the sea-side will be sure to find, if he search faithfully for them. But first as to the sea-urchins (Figs. 26, 27). If one would study these strange forms, he must seek for them in the deeper pools left by the tide. Nor is a casual glance into the pool sufficient to reveal the prize

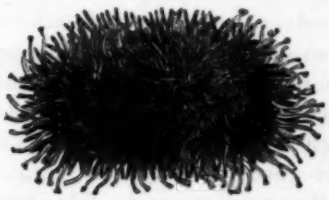


FIG. 26.—SEA-URCHIN (*Toxopneustes drobachiensis*, Agassiz).

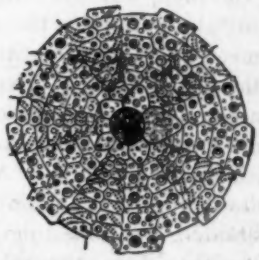


FIG. 27.—TOP-VIEW OF SEA-URCHIN, SPINES REMOVED. Shows ambulacral and interambulacral plates.

which he is in search of. The beginner may look into a clear pool where there are a hundred sea-urchins, and perhaps he will not see one until he has looked for some minutes; for sea-urchins not only resemble some of the sea-weeds in their color, but by means of their locomotive suckers they draw the sea-weeds closely about them, in many cases completely concealing themselves. If the collector reach down into the water the full length of his arm, and move his hand over the bottom among the sea-weeds, he will not be long in finding a sea-urchin. He will know when he touches one, as the sharp spines stand out on every side. Without moving from his position the collector will often secure a score or more of fine living specimens—some hardly exceeding a fraction of an inch in diameter, and others two inches or more; for he will find them of different ages, even if not of different species. Should he put them in a shallow pool while he goes on collecting, and then look for them again, he will at first think they have escaped into the sea or into some hole; for, true to their instincts, no sooner are they uncovered than they begin to conceal themselves again by drawing around them the sea-weeds by means of their long locomotive suckers. If we turn one over on his "back," that is, place the mouth upward, the urchin immediately begins to turn itself, and in a short time will regain its natural attitude, mouth downward.

The spines are very remarkable, not only in their appearance, but in their structure. A cross-section of one, under a microscope, reveals a structure so perfect and so beautiful that the richest mosaic is but rude masonry as compared with this natural mosaic.

Situated among the spines are curious three-pronged forceps, which have much puzzled the naturalists in days gone by; for it was doubtful

what is their real function. But, at last, Agassiz—the younger Agassiz, I believe—discovered that these curious organs, called pedicillariæ, are for keeping the spines clean.

The mouth of the sea-urchin is provided with five pointed teeth, which shut together on a common centre; and these teeth can all be removed together, and, thus removed, they present quite a curious appearance, and are known among naturalists as "Aristotle's lantern."

The shell, which is composed of hundreds of pieces, presents a very beautiful sight when the spines are removed. It is made up of ten segments, radiating from the mouth, and converging to a central region on the top (Fig. 27). Every alternate segment is perforated for the numerous locomotive suckers to pass out, the intermediate segments being imperforate, and more prominently marked with tubercles, on which spines are borne. At the termination of the five perforated segments there is a triangular plate with a minute opening; here the eye is situated. Alternating with these five plates are five larger ones, each with a hole, through which the eggs are laid. The largest of these plates is the madreporic body, corresponding perfectly to that seen on the starfish, already spoken of, and which doubtless acts as a sieve or water-filter.

As sea-urchins do not shed the shell, as do crabs and lobsters, the inquiring mind will naturally ask how the animal can continue to enlarge when once it is invested with a hard shell. The answer is, that every piece of the shell grows at the same time, and in this way the whole shell enlarges together, and in a perfectly symmetrical manner.

As already indicated, the sea-urchin moves by means of its locomotive suckers. Extending these beyond the spines, it lays hold of the surface of the rock or sea-weed, and then, contracting the suckers, pulls itself along. And these suckers can be extended quite a distance beyond the spines. For example, a sea-urchin can extend a sucker from near the top of the shell, and bend it over, and lay hold of the surface upon which the animal is resting.

The sizes and forms of sea-urchins are very numerous. The ordinary kinds are two or three inches in diameter; some of the elongated kinds in the tropics have a diameter of five inches or more. Some are nearly hemispherical; others rise in the centre so as to be almost a cone; others are flat, and are known as cake-urchins (Fig. 28); others are more or less heart-shaped, etc. Some of the cake-urchins are curiously modified, as seen in Fig. 29.

On the coast of Maine especially, but also along both shores of the Atlantic, as well as in most other parts of the world, the sea-shore visitor will find the "sea-cucumber" appearing not very unlike a cucumber while it still retains the blossom upon its end. On the coast of Asia it is known as trepang, and is the animal which the Chinese use so extensively for food. Aristotle called it *Holothuria*, but for what reason he does not tell us, and we can only conjecture. The dead

specimens give us but little idea of this animal. It must be seen and studied while in the sea or in the aquarium, in order to be appreciated. When dead, the suckers—which are like those of starfishes and sea-urchins—are retracted, and the tentacles are also in a mass, and the

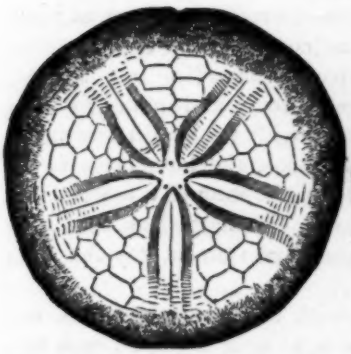


FIG. 28.—CAKE-URCHIN (*Echinarachnius parma*, Gray).

FIG. 29.—KEY-HOLE-URCHIN (*Mellita quinquefora*, Agassiz).

whole form is shriveled. But in the water the form is full, and the fringed tentacles are extremely beautiful, and can properly be compared to the delicately-branched and beautifully-colored sea-weeds which we all so much admire.

The "sea-cucumber" has a wonderful power of changing its form. It elongates, contracts, enlarges at each end while it is small in the middle, and thus changes its appearance from time to time. In its power of going to pieces it almost excels the "brittle-star" and the

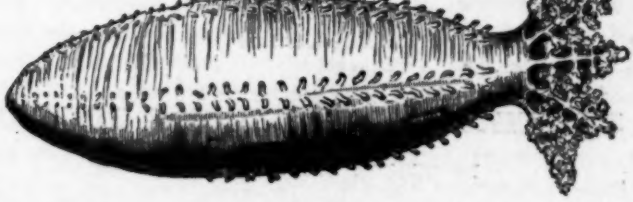


FIG. 30.—HOLOTHURIAN, OR "SEA-CUCUMBER" (*Pentacta frondosa*), North Atlantic.

starfish, *Liudia*, already noticed. It breaks off its tentacles, and yields up other parts, at will; and it has been known, when disturbed, to eject all its internal organs, thus leaving itself only an empty sac!

The "sea-cucumber" has no hard parts, excepting the merest calcareous particles imbedded in the thick, leather-like covering. These

are of various and remarkable shapes, and are very interesting objects when seen under the microscope. They are the representatives of the calcareous plates which make up the hard shell of the sea-urchin.

Unlike as are the crinoid, brittle-stars, star-fishes, sea-urchins, and sea-cucumbers, in their form and general appearance, they are but different expressions of one and the same fundamental idea. They are all radiates, all possess calcareous plates—though these are at their minimum in the sea-cucumbers—and are covered with spines, tubercles, or a rough skin. They are all constructed according to a reigning number, the principal parts being in fives, or some multiple of five. If we imagine the sea-cucumber to be placed with its mouth downward and the tentacles to be replaced with teeth, the long body to be shortened upon itself so as to assume nearly the form of a hemisphere, and the microscopic calcareous particles to be enlarged so that they should touch one another, then we should have essentially the form and structure of the sea-urchin.

And if we imagine the sea-urchin with its segments spread out into a star-like form, instead of being brought near together, each perforated segment taking half of the imperforate one, and at the same time the spines to be reduced to tubercles and the plates to a network, then we should have essentially the form of a starfish.

Again, if the starfish had its body reduced to a well-defined disk, and its arms starting out abruptly from this disk, we should have all the most prominent features of the serpent-star.

And if the serpent-star had its mouth placed upward, its arms multiplied by branching, and its ab-oral region elongated into a stem, we should have the plant-like form of the crinoid.

And so it is in all parts of the material world. Nature has but comparatively few great types, but the forms included under these types are almost endlessly varied. Unity in diversity is a great law which prevails not only in the animal kingdom, but throughout the whole realm of Nature.

THE SCIENTIFIC STUDY OF HUMAN TESTIMONY.

By GEORGE M. BEARD, M. D.

III.

OUTLINE OF THE RECONSTRUCTED PRINCIPLES OF EVIDENCE.—Even a qualified admission of the soundness of these views also compels the admission that the reconstruction of the principles of evidence is the crowning need of philosophy.

Such reconstruction will not be made on the base of Pyrrhonism, or the denial of the possibility of knowledge—for knowledge is possible,

although it is relative to the human faculties. The revision of human testimony that physiological science now requires, and is qualified to undertake, is radical and revolutionary, but it is not suicidal; it is discriminating, not sweeping; not destructive, but constructive.

The demand is not for the rejection but for the reconstruction of human testimony; and the spirit with which this should be undertaken is not skeptical, but scientific.

This reform of logic, like all revolutions in science, should advance under the guidance of the *scientific method.* By the scientific method, I mean that method of obtaining and organizing knowledge which consists in defining, so far as is possible to expert human faculties, the *boundaries between the possible and the probable, between the known and the unknown.*

The scientific method can only be successfully used by those who are endowed with, or by discipline have acquired, what I am accustomed to call the *scientific sense,* by which phrase I mean the power of seeking truth through the intellect alone, uninfluenced by the emotions. For the tendency of truth, the scientific sense has no hopes and no fears, except so far as it may help to find the truth.[1]

The scientific method is a part of the evolution of culture, of science, and of civilization; to absolute savagery everything is absolutely known; all natural phenomena are pronounced supernatural; with the beginning of knowledge there is a recognition of ignorance, which, in time, gradually subdivides so as to include all phenomena that can be brought to the attention of the human mind in one of these four grand divisions—the *possible,* the *probable,* the *known,* and the *unknown.* The constant effect and sign of progress in knowledge is the narrowing of the area of the known and the probable, and the extension of the areas of the unknown and the possible.

I. *The corner-stone of the reconstructed edifice of the principles of evidence must be the recognition of the necessity of the testimony only of experts in all matters of science, and consequent absolute rejection of all testimony of non-experts, without reference to their number or the unanimity of their testimony.*

A few definitions are here needed:

Science is systematized knowledge.

An expert is one who can see all sides of a subject.

A non-expert is one who sees but one or a few sides of a subject that has many sides.

[1] The philosophy of the world has almost always been the servant of delusions. The most eloquent passage in Sir William Hamilton's "Logic" is that in which he enjoins on the philosopher the duty of seeking truth for its own sake, and there are few or no philosophers who would not in the abstract subscribe to this sentiment, but concretely and practically nearly all human reasoning on logic and the principles of evidence has been exercised for the special purpose of proving what is absolutely undemonstrable or absolutely untrue.

The tests of scientific expertness are—distrust of the senses; the recognition of the relation of induction to deduction; avoidance of all sources of error, in observation, experiment, or reasoning; the appreciation of the relative importance and non-importance of real or supposed facts; the ability to distinguish reality and its semblance, especially between the subjective and the objective; and, what indeed follows from the other three tests, the maintenance of mental equilibrium during experimental researches. The reputation of an expert is acquired primarily through other experts, and secondarily through the judgment of mankind. Expertness has its various degrees; there are experts, and experts, and experts: the highest experts are the originators, the explorers, the pioneers, the founders, the creators of science; the lowest experts are the followers, the gleaners, the treasurers, the curators of what others have discovered, and who simply repeat and retain the experiments of genius. The highest experts—the Newtons and Galileos, the Harveys and Jenners of science—must stand at first alone, with no other expert at hand, by which to estimate their relative heights and strength; it is their necessity and their glory to educate experts, by whom their own merits are to be tested; they must create the standard by which they are to be judged; their critics will be their own offspring. For many years Newton was the only man on this planet who understood the theory of gravitation, or was able to criticise it.

The tests of scientific non-expertness are, blind repose in the senses, the inability to eliminate or appreciate sources of error in observation, experiment, or reasoning; the non-appreciation of the relative importance of real or supposed facts; the confounding of semblance with reality, and particularly the subjective with the objective; liability to be entranced, or to have the emotions unduly excited, in the presence of genuine or supposed phenomena; and the use of induction when only deduction is valid, and *vice versa*.

Expertness in one branch of science not only does not qualify, but in various ways may disqualify, one to be an expert in another branch.

That skill in mathematics unfits one for the successful study of various other specialties was pointed out long ago, both by Abercrombie and Hamilton; but the antagonism of specialties may be traced, under recent experience, yet more minutely, for it is found that eminence in physics, or chemistry, or astronomy, may thoroughly unfit one for the study of physiology; and within a few years some of the greatest blunders recorded in the history of delusions have been made by naturalists, chemists, physicists, jurists, and astronomers of unquestioned honesty, real genius, and deserved eminence, making, or attempting to make, discoveries in the new and almost unexplored realm of cerebro-physiology—experiments with living human beings. The worst blunders in the world are scientific blunders—the unconscious slips of justly eminent men, who do not know that their very eminence in one sphere forbids them to undertake another.

Coöperation of Experts.—There are claims that can only be settled by a coöperation of experts, in different branches of science. In regard to the question of the relations of experts to each other in the investigations of claims, it is to be observed that a claim should *primarily* be referred to that *specialty that is best capable of dealing with it by deductive reasoning.* Claims that can be settled by the principles of logic, without the aid of special scientific knowledge—such as, from the limitations of the human faculties, can never be proved or disproved—are to be referred to logicians. If the known principles of any special science, to which a claim is referred, deductively disprove any claim, it is unscientific for any expert in that science to examine or discuss it, save as an amusement, or for the sake of the incidental facts that an investigation may develop. If the claim refer to an open question, the primary expert is to judge whether the coöperation of experts in other branches of science is needed. If the claim belong to a department not yet organized into science—the territorial or preëxploratory stage—in which there are no experts, there are none to decide upon its merits, and the world must remain in ignorance until the experts appear; but the world, in its impatience and ignorance of logic, practically refers such claims to leaders in various branches of science, or to men of general ability and honesty, who almost always reach erroneous, if not ludicrous, conclusions. Such was the origin of the delusions of "animal magnetism," and "odic" and "psychic" *force*—claims that belong to cerebro-physiology, a department of science that is now but just passing out of the territorial into the organized stage.[1] When experts blunder, as they may, their conclusions should be revised, not by the people, but by other and better experts.

II. *The reconstructed principles of evidence require that the quality and quantity of evidence necessary for proof of any claim depends on the nature of the claim.*

The principles of evidence that have heretofore commanded the world's acceptance make no distinction in the quality or quantity of testimony for different varieties of claims; the discovery of a new planet is as credible as the daily rising of the sun; the introduction of a new force needs no more and no better auspices than the observation of the

[1] Mr. William Crookes, in his kindly and complimentary remarks on my theory of trance, as republished in the London *Quarterly Journal of Science*, January, 1878, observes that there may be a physical side to physiological experiments. The suggestion is so far forth a valid one; the reply is found in the above analysis. The question whether there is in the human body a new and unknown force belongs to cerebro-physiology, and, not being disproved deductively, should be referred to those experts in that specialty who understand how to experiment with living human beings; and it is for these primary experts to decide whether the experiments they may make require the coöperation of physics, or chemistry, or other branches of science. There may also be a physiological or pathological side to physical experiments; thus the "etheric force" of Mr. T. A. Edison was primarily a question of physics, but for its investigation needed and obtained the coöperation of physiologists.

established phenomena of an old one; the passing from death into life is to be received with as little question as the passing from life into death. Under this feature of current logic delusionists of all kinds have consistently and persistently found refuge.

The different classes of claims in regard to real or alleged phenomena, in their relation to the quality and quantity of evidence needed to prove them, may be thus presented in order of climax:

1. *Claims as to unsystematized knowledge or matters of every-day life.*

Under this head comes most of the testimony commonly given in courts of justice. For claims of this kind experts are not usually required, and the mistakes which are constantly made, every hour and every moment, are of comparatively trifling account, since they affect individuals and not general principles.

It is one of the innumerable proofs of the limitations of the human brain, that the rules of evidence in our courts of justice, although practically, on the average, as good, with some exceptions, as can be expected for the obtaining of legal justice, necessarily imperfect and uncertain, are yet, in many respects, to the last degree unscientific. The exclusion, for example, of hearsay testimony, and of the testimony of a wife against her husband, and the modes of questioning and cross-questioning of witnesses make it oftentimes impossible to obtain justice. The scientific man, desirous not of gaining a point but of ascertaining the truth, and recognizing the untrustworthiness or uncertainty of nearly all human testimony, would in many cases prefer hearsay to direct statements, and would give more for the evidence of a near relation or a wife than for that of all the world besides.

One needs but to follow the details of a few great causes, as the McFarland trial, the Beecher-Tilton, the Tichborne, and the Vanderbilt cases, to see that by the rules of evidence, or at least by the actual practice of courts, testimony which scientifically is valueless is admitted, while the only testimony that is, or promises to be, of any scientific value is systematically excluded.

The great advances in science have not been made in courts of justice. Even when on questions of science experts are called to testify, their testimony is obtained in such a way as to impair, if not destroy, its value, and to obscure more than to reveal the truth.

From the scientific point of view, a legal trial is really an experiment with living human beings, and, like all experiments of that kind, is liable to *six* sources of error, all of which must be guarded against if we are to find the exact truth. The science and art of experimenting with living human beings are not yet understood, even by physiology and pathology, to which department they belong.[1]

[1] That the art of experimenting with living human beings is now but in its early childhood is shown by the fact that all those who give special attention to the physiology

2. *Claims as to general or special facts of science that are already established by the investigations of experts.*

Here we rise in the scale of evidence, but do not require experts. What is bad or useless evidence for original demonstration may be satisfactory, or at least tolerable, for confirmation. The phonograph, prior to its invention, was credible only on expert authority; stories relating to it may now be received on the statements of non-experts, for, although they may be erroneous, they do not in any way affect science.

III. *Claims as to facts or phenomena which have not yet been established by experts in the special science to which they are to be referred, but which may yet be proved true by the experts of the future.*

Here we take a long step in the ascending scale of evidence; we come to claims that cannot be proved by any amount of non-expert evidence; which may be true, or may be untrue, as experts only shall determine. A type of this class of claims is that of the sea-serpent, of whose existence there is now no proof, but which zoölogists might possibly introduce into science. Testimony which is sufficient to arouse the attention of experts, and induce them to investigate claims that are made by non-experts, may yet of itself have no value in science.

Types of this class of claims are supposed new forces in Nature, the existence of which can only be established by the highest experts in the branches of science to which they respectively belong. The claims of "odic" force and "psychic" force, and of "animal magnetism," are excellent illustrations: although believed by thousands and thousands of people of average intelligence, and by a number of eminent non-experts in science, they are yet instinctively rejected, not because there is any positive deduction against them, but for the reason that experts have never been able to find a shadow of proof of their existence, but, on the contrary, have been easily and abundantly able to show that all the real phenomena supposed to indicate the presence of these unknown forces can be explained by the laws of forces already known. An illustration, belonging in part to a different branch of science, was that of the alleged new force, between light and heat on the one hand, and magnetism and electricity on the other, said to have been discovered

and pathology of the nervous system do not, in their experiments, even suspect the elements of error involved. During the past year one of the very ablest of neurologists—Charcot, of Paris—has published accounts of experiments in so-called "metalloscopy" and "metallotherapy," in the making of which, according to his own statements, one of the most important of the six elements of error (as indicated in a paper on "Mind-reading," in a previous number of this Monthly), mind acting on body, seems to have been ignored or ill understood, or at least not scientifically provided for. The experiments of the committees of the French Academy with "animal magnetism," "mesmerism," and "clairvoyance," of Crookes with Home, of Wallace and Zollner with Slade, are open to the same and also numerous other criticisms. From such accounts of such experiments, even an expert cannot tell what did or what did not happen; it is therefore unscientific to discuss them.

two or three years since by Mr. Edison, the renowned inventor of the phonograph. This claim belonged primarily to physics, and secondarily to physiology, and was carefully investigated by many physicists and some physiologists of this country and Europe, and by them it was decided, rightly or wrongly, that the claim was not proved, that the spark supposed to indicate a new force represented a hitherto undetected phase of induced electricity.[1]

IV. *Claims which, from the limitations of the human faculties, can never be proved or disproved.*

Claims of this kind may be indulged in as speculations, with the understanding that they are merely speculations; but to seriously discuss them, with the purpose of ascertaining their truth or falsity, is unscientific.

Under this head all supernatural claims must be included, for the reason that it is impossible for the human faculties to distinguish between what is unknown in Nature and what is above Nature. The narrow limitations of our knowledge of Nature all will admit. What expert professes to exhaustively know Nature even in his own department? What, indeed, is all our knowledge but an infinitesimal fraction of our ignorance; a flower or so plucked from a boundless garden; a few ores dug from measureless mines; a slight clearing in an infinite wilderness; "a film on the ocean of the unknown?" Leaving out of view all questions of supernaturalism and all the phenomena of life, what do we know, or, in this world, have we reason to expect to know, of inorganic Nature? What is light? What is heat? What is gravity? Why should one mode of motion make one form of force and not another? Toward the solution of these primal questions—that the infant can ask and the philosopher cannot answer—the sciences and reasoning of all the centuries have made, and are destined to make, no advance.

Even if an expert could be supposed who should exhaustively know Nature in his own department, how could he know that he knew it? Not knowing that he knew all Nature in his own realm, what tests would he have—could he have—to distinguish between the supernatural and what might be unknown in Nature? If, to go to the outermost verge of conceivability for illustration, the clock of the universe were turned back to-morrow, and the sun should thereafter rise in the west instead of the east, how would it be possible to prove, in a scientific sense, that a supernatural event had occurred?

Every phenomenon that can be brought to the attention of the human faculties must be referred to one of these three classes:

1. The known in Nature.
2. The unknown in Nature.

[1] Mr. Edison's views, as he writes me, are unchanged. His experiments, and my own made in coöperation with him, as well as a discussion of the bearings of the claim on the principles of evidence, were published two years since.

3. The supernatural, or above Nature.

In investigating any new claims whatever, experts—consciously or unconsciously—keep this order in mind: they first inquire whether the claims can be explained by laws already known to experts; if not so explained, then they are referred to the second order—the unknown in Nature—and attempts are made to bring them into the first order, or the known in Nature: such is the philosophy of all human progress in science. But when men go further, and assert that these unknown phenomena are of supernatural character, they bid good-by to the scientific method; for what is it that constitutes the differential diagnosis between the unknown in Nature and the supernatural? It matters not, in its bearings on this question, how the supernatural is defined, as the unusual action of natural laws or interference with natural law. The supernatural manifested becomes, relatively to the human faculties, the natural. For all that we know, or can know, every great or minute phenomenon in Nature may be a direct, immediate, and special act of a power above Nature: the movement of every star, each vibration of the infinite ether, the shock of earthquakes, and the silent meaning of protoplasm, may all be manifestations of a power above Nature; but, whether they are so or not, the human mind is powerless to prove or disprove. The universe might swarm with demons and angels; ghosts might inhabit the earth and sky, in numbers compared with which the population of the globe is as the seen to the unseen stars; spirits might speak, might rap, might materialize—and yet the human mind would be unable to scientifically prove the supernatural, for still the question, how to distinguish what is above Nature from what is unknown in Nature, would remain unanswered and unanswerable.

Science has not, cannot have, any absolute deduction against the existence of ghosts, or of spirits, evil or good, or of any imaginable supernatural shapes whatsoever; the world might be embraced and permeated by an infinite spiritual ocean, as the air is believed to be penetrated by a luminiferous ether; but science would not have, and could not find, either through induction or deduction, any way of demonstrating its existence. In the realm of the supposed supernatural all things are possible and all things are undemonstrable.[1] Under this class of claims, that from the limitations of the human brain can neither

[1] Although it hardly comes within the scope of the present outline to point out all the practical bearings of this reform in logic, one thought may perhaps be briefly suggested. For the cause of religion, it is fortunate that it cannot be scientifically proved. Religion, being a recognition through the emotions of a spiritual universe and of our relations to it, cannot and should not appeal to the intellect. A religion scientifically proved would be a religion no longer, but a fact of science, like the Copernican theory, or gravitation, and, like these and other scientific facts, would be taken cognizance of by the intellect alone, consequently it would lose entirely the leverage of the emotions, by which it has so powerfully influenced the destinies of mankind. The scientific demonstration of religion would be the destruction of religion.

be proved nor disproved, are the conventional definitions of matter, and accepted distinctions between matter and mind, or other forms of force.

The qualities that for ages have been attributed to matter, as inertia and extension, apply correctly enough to that limited portion and form of matter that the senses can appreciate; but, as has been shown, all but an infinitesimal portion of Nature is permanently sealed against the senses. What warrant have we, beyond undemonstrable probability, that the attributes of that portion of matter that can be reached by the senses belong also to all that portion of which the senses can directly teach us nothing? How do we know that the familiar forces, as light, heat, electricity, and gravity, may not be as truly matter as the Atlantic Ocean or Mont Blanc?

Standing on the outermost verge of conceivable science, and casting the line of probability into the dark unknown, as far as it is possible for human weakness, will it, can it reach any more rational generalization than this, that all Nature is unity? Whether the common axioms of human reasoning—such as the whole is greater than a part, every effect must have an adequate cause, every thought must have a thinker, a thing cannot be and not be at the same time—do or do not apply to the supernatural, the mind of man is powerless to determine.

Under this head come all conceivable questions relating to the existence and nature of other universes than ours.

A question of great interest, or would be if it could be answered, is that of spontaneous generation, which from the limitations of the human senses can neither be proved nor disproved.

How is it possible for the human faculties to determine what degree of heat any supposable living substance, or intermediate substance between living and non-living, beyond the reach of the microscope, may bear? There are gradations of endurance in living things that are accessible to the senses. What are the limits of this gradation through the realm of the infinitely little? If, therefore, all experts in this branch of inquiry should agree that fluids subjected to a very much higher degree of heat than has yet been employed in experiments of this kind shall yet, when every conceivable precaution against sources of error has been taken, develop some of the lower forms of life, the question of spontaneous generation would still be an open one.

The present and prospective state of the spontaneous generation question is, then, as follows:

1. Science has no absolute deduction for or against it.

2. It is impossible by present deduction or by conceivable induction to either positively prove or disprove it.

Discussions on the subject, like that between Tyndall and Bastian, are on both sides unscientific, as they are unsatisfactory, and would not be indulged in by those who have correct ideas of the limitations of the senses.

V. *Claims which are absolutely disproved by deductive reasoning, and which therefore the special sciences to which they belong know to be false without any examination.*

Among the more prominent of claims of this kind are those that relate to squaring the circle, flatness of the earth, perpetual motion, including "Keeley" and "Winter" motors, alchemy, astrology, "four dimensions of space," levitation, mind or thought reading, clairvoyance or second-sight, including prevision and retrovision.

To examine or discuss claims of this kind, for the purpose of determining their truth or falsity, is not only useless, but unscientific. In science there are three unpardonable sins—trusting the senses, non-experts attempting to do the work of experts, and using deduction for induction, or, *vice versa*, induction when only deduction should be used, as in the class of claims here under consideration.

The reconstructed principles of evidence explain the following problems in psychology, to which hitherto, so far as I know, no solution has been offered:

1. *Why the logic of the schools has always been on the side of delusions.*

For those who accept non-expert testimony science is the only delusion: everything is true except the truth. In the long discussion relating to various modern delusions between Mr. Wallace and Dr. Carpenter, Mr. Wallace, according to the rules of evidence, has throughout the best of the argument: his reasoning, for those who trust their senses, who believe that non-experts can do the work of experts, and who use induction when only deduction should be used, is unanswerable.

Likewise in all, or nearly all, the world's memorable contests between science and delusions, the truth has prevailed, not by virtue of logic, but in spite of it; the instincts of mankind—the one saving clause in the constitution of the human brain—rising up in their unconscious majesty, and vindicating their rights and their power against the tyranny of the senses and the cruelty of the syllogism. Logically, Copernicus and Galileo were wrong; and their accusers, backed by the concurring testimony of the eyes of all mankind through all the generations, have to this hour never been answered. Only on the side of error is there consistency; during all these recent days, when science sets its forces in array against any dominant delusion, as "animal magnetism," or "odic" force, or "psychic" force, or "spiritualism," it first closes its books of logic and forgets all the teachings of the university.

2. *Why men of culture and genius, and especially of logical attainments, are more easily and profoundly deceived by delusions than men of ordinary ability.*

The history of all delusions, so far as known, establishes the wisdom of the maxim of the father of modern conjurers—the famous Houdin: "It is easier to dupe a clever man than a fool." Jugglers, and illusionists,

and sleight-of-hand performers of every grade, prefer examining committees composed of leading citizens—the ablest jurists, physicians, merchants, clergymen, scientists, and men of letters that can be found—and instinctively dread the criticism of children and of day-laborers, who, being unable to read, or write, or to think, or to reason according to the books, are obliged to trust their instincts.

The world's greatest follies and darkest untruths, especially while in the process of dissolution, have always found some justly honored authority in theology, in literature, in philosophy, in law, and in science itself—a Matthew Hale, a Lord Bacon, a Wesley, a Cotton Mather, an Elliotson, a Hare, a Gregory, a Wallace, an Emerson, an Agassiz, a Zollner, committees of learned academies, professors in great colleges—to stand by their bedside, armed with syllogisms, trusting their senses, and conscientiously striving to nurse them back to vigorous life. This grotesque phenomenon of history—so universal as to command general observation—would seem to have this threefold explanation: 1. The fact here suggested, that clever natures trained in logic are obliged to reason logically, and, as the logic of the world is wrong, they arrive at the wrong conclusions, which, against the protestation of their instincts, they are forced to accept. The greater the man the greater his errors; the weakness of the world confounds its strength; ignorance is saved by its instincts, which science and logic dare not always trust. If the chart be wrong, the navigator who accurately steers by it is sure to go out of his course; while he who goes by blind reckoning may possibly float into harbor. 2. The social and professional position of men of genius and ability is constantly compelling them to undertake investigations in departments in which they are not authorities, and requires them to proclaim positive decisions which, like the results of all non-expert investigations, are almost inevitably erroneous. 3. The faculty of wonder that so often leads to credulity is not inconsistent with the highest scientific genius; it is, indeed, a powerful and determining element in the scientific character, and thus what has been called "the foundation of all philosophy" also becomes the foundation of all folly. Such, as it would appear, is the solution of the problem which for so many years has been the despair of the historian and the opprobrium of psychology.

Hence it is that there are no superstitions that are so superstitious as the superstitions of scientific men. Hence it is that all delusions in their decline cast their last shadows over the loftiest heights of science, of literature, and philosophy.

ON THE FORMATION OF NEBULÆ.

By WILLIAM M. DAVIS, Esq.

THE close proximity of the satellites of Mars to their primary has led me to investigate the lesson taught by them and other satellites of short periods.

This investigation has enabled me to demonstrate:

I. That the nebular hypothesis fails to account for the present condition of the solar system, without the additional hypothesis of a resisting medium in space.

II. It has enabled me to show, also, that, although this medium tends to bring the solar and all other systems to a state of quiescence, it has no such tendency on the material universe as a whole, provided that the ponderable matter thereof be of *infinite* extent. If, however, the ponderable matter—as distinguished from the ether—be of *finite* extent, it should come to rest, as will be shown in the sequel.

The first proposition will be established by taking the first satellite of Mars as an example, and proving that *it* must have been at least fifteen or twenty times as far as it now is from its primary when it was able to take on the globular form from the nebulous ring out of which it was made. This being established, it follows, as a necessity, that its orbit must have contracted into its present dimensions since it was thus formed; and the satellite during this time has condensed into its present condition.

As the same cause which contracts the orbits of the satellites should produce a like result upon those of the planets, it follows that *they, too,* must have been farther away from the centre of the system than they now are, when they took on the globular form from their nebulous rings.

The hypothesis of a resisting medium has been adopted to account for this contraction of orbits, as no other hypothesis seems competent to do so.

That this satellite of Mars and others in our system were much farther away from their primaries than they now are, will be proved, by proving that, if a nebulous satellite revolved around any primary in the short period in which most of the solid ones now do, the tidal energy—or tendency to elongation and disruption—which would, in that case, be generated on its opposite sides by such rapid revolution, would be sufficient to tear it into atoms. These atoms would be distributed around the primary in the form of a nebulous ring, which ring would be in a state of *stable equilibrium*, and therefore could not be reconverted into the globular form.

Permit me, then, to bring forward some imaginary experiments, for the purpose of illustrating certain dynamical principles (and methods) to be employed in proving the fact just stated.

Assuming the density of the earth to be 5½ times that of ice, it follows that, if a globe of ice—say ten miles in diameter—be isolated in space, a small dense body, as a bullet, near its surface, should fall toward it—by the action of its gravity alone—through 160 inches during the first minute of its descent. Now, if this icy globe be made to revolve around any large planet in the short period of 5 hours and 42¾ minutes, and on its axis in the same time and in the same direction, then the tidal energy (which is, in this case, the difference between the force of the planet's attraction for the particles at the centre of the icy satellite and for those at the two opposite points of its surface which are nearest to and farthest from the planet, added to the difference of the tangential force on the particles)[1] would exactly counterbalance the icy satellite's interior gravity along this diameter; i. e., if the tidal energy could be made to act alone on the aforesaid bullet, at either end of this diameter, it would force it outward through 160 inches during the first minute of such action; hence, if a particle at either end of this diameter should be acted upon both by the gravity and the tidal energy at the same time, it would have no tendency to move in either direction; but if it were raised a few inches above the surface, then the tidal energy would prevail over the gravity and take it away.

To get a clear conception of the peculiar condition under which this icy globe is now placed, let us call this last-named diameter its axis of tension, and the plane passing through its centre and perpendicular to it the plane of compression.

Now, along this axis there is no force to prevent the elongation of the icy globe in that direction, except only the force of cohesion in the ice itself, as its gravity in that direction is exactly counterbalanced by the tidal energy.

Around the plane of compression, however, the case is different; here the interior gravity is unopposed by the tidal energy, and every atom is pressing inward on the central mass; and this pressure tends to force the tensible regions outward, and thus to make the tensile axis longer.

When this elongation begins, the disruptive energy rapidly increases in virtue of the increased diameter in that direction, and the diminution

[1] The above is the formula usually given for computing the tidal energy under the assumed conditions; but I incline to believe that the real disruptive power exerted on the satellite is just double that, for the following reasons:

One (1) pound of ice placed on the surface of this icy globe should press it with the force of 1.6 grain, of our standard.

Now, the tidal energy, as above calculated, causes the planet to pull the nearest pound with 1.6 grain greater force than it does the central pound, while, at the same time, it pulls the central pound with practically 1.6 grain greater force than it does the farthest pound; consequently the tensile pull between these two surface-pounds, which would be required to resist the tidal energy, must be equal to 2 × 1.6 grain, while they are drawn toward each other by the gravity of the satellite with the force of only 1.6 grain.

of the internal gravity, produced by the same operation. By such action as this the icy globe should be quickly torn into pieces and distributed around its primary in the form of a ring of fragments.

Prof. Daniel Vaughan has shown that such is the origin of the rings of Saturn, and ascribed the close approach of the two satellites which formed them to the action of a resisting medium.[1]

If this were a globe of water instead of ice, it is very evident that much less disruptive energy would be required to tear it to pieces, on account of the greater mobility of its parts; most probably not more than one-seventh of the above-named force would be required to accomplish this result.

If this force be sufficient, and the globe of water be made to revolve around any large planet in fifteen hours or less, the tidal energy will tear it into atoms by virtue of the following law:

It can be demonstrated—1. That the tidal energy generated on a spherical satellite of small but constant mass, when revolving around a large primary, varies *directly as its diameter;* 2. That it varies, also, *inversely as the square of its periodic time;* and 3. That the ability of the same satellite to resist the disruptive tendency of this tidal energy varies *inversely as the square of its diameter;* provided there be no cohesive force to aid in resisting this tendency, and in a nebulous satellite there would be none to do so.

As the first and third propositions relate to the diameter, they may be included in one, and then the law may be stated as follows:

The disruptive ability of the tidal energy of a primary planet on a nebulous satellite of small but unvarying mass varies directly as the cube of the diameter and inversely as the square of the periodic time. Let us apply this law to the case in hand. To do this it may be very safe to estimate that a ten-mile globe of water, while yet in the state of a nebulous satellite, would occupy the globular space of at least one hundred miles in diameter. This would give it a density of only $\frac{1}{1000}$ of that of water, which, however, would still be millions of times greater than that of the original nebula out of which the entire system was made.

According to the above law, the disruptive ability of the tidal energy on the nebulous satellite must be 10^3, or 1,000 times as effective as on the ten-mile liquid one, if revolving in the same time. Now, to find the shortest time by the above law in which this nebulous globe could revolve around its primary without disruption, we must multiply the fore-named fifteen hours by the square root of 10^3; the product of this multiplication amounts to about 19¾ days. As this is the shortest time in which *any* small nebulous satellite of this density can revolve around *any large primary* without disruption, it becomes very evident that nearly all the solid ones in our system must have been

[1] "Popular Physical Astronomy," by Prof. Daniel Vaughan. Cincinnati: Freeman & Spofford. 1858.

much farther than they now are from their primaries, when they were able to take on the globular form from the nebulous rings or collection of nodules out of which they were made.

Taking the above estimates, and applying the law to the case of Mars's nearest satellite, we find that its orbit must have been at least 17⅞ its present diameter when it was able to take on its globular form from its nebulous ring.

This establishes beyond doubt the fact to be proved, and gives us some idea of the vast dimensions of the solar system when this last nebulous satellite of Mars was formed.

What, then, must have been the distance of the *first* nebulous planet from the centre of the system, when *it* was formed? This, of course, can be only vaguely guessed, as we have no reliable criterion to judge by.

THE RESISTING MEDIUM.—The introduction of the hypothesis of a resisting medium to account for this contraction of planetary orbits seems at first sight to involve a condition fatal to the continued activity of the material universe; for, if there be a resisting medium, which is gradually bringing our system to a state of rest by its reaction on the bodies moving in it, it is but reasonable to suppose that it should produce like results on all other systems, and thus ultimately bring the entire universe of matter into the quiet sleep of death. But that this is not the normal tendency, however, when applied to the universe *as a whole*, we have the most abiding assurance, without any investigation of this kind; for, if such be the tendency now, it always would have been the tendency, in which case the end would have been accomplished during the eternities of the past, and we would not be here to-day to dread its approach.

Still the following question, or its equivalent, will press itself on many minds: How can the perfect conservation of force, which is so essentially necessary for the continued activity of the material universe, be reasonably accounted for, if there be a resisting medium in all space through which it must ever move? This pressing yet interesting question leads directly to the second division of our subject, which will now be discussed.

In order to give this question a suitable reply, as well as to show *how the perpetual activity of the material universe may be maintained*, while moving in this resisting medium, we will trace the history of some given solar system from its original nebulous state, down through its life-sustaining period, thence to its final destiny; and then discover, if possible, a means by which it may be reinvigorated or resurrected to a new planetary life. For this purpose it seems necessary to present —very briefly, however, for want of space—one illustration, reaching through the various stages in the grand round of successive changes through which all planetary systems seem to be passing. Our solar system will be taken as the illustrative example.

In tracing the history of the system from its nebulous state down

to the present time, the path pointed out by the illustrious Laplace will be closely followed.

More recent writers have suggested other modes for the formation of such systems, some of which, however, would seem to be the exception instead of the rule here presented, as the sequel will show.

No definite explanation will be given in this paper as to how the out-thrown masses of nebulous matter—which will hereinafter be described—may be utilized in forming other systems; and no suggestion given as to the formation or structure of the globular or other clusters of stars, which are so bewildering to investigate, and yet so interesting to look upon; but the formation of these, and of that great galaxy of stars of which our sun seems to be a member, may be accounted for on the same dynamical principles that are employed in this discussion.

Following Laplace, it is assumed, then, that our planetary system began its evolutions as a great nebulous sphere of perfectly dissociated matter of almost inconceivable rarity, and of nearly uniform density.

At this time it was not quiescent, but most probably was agitated by the movement of internal currents and counter-currents, the resultant motion of which caused the entire mass to revolve around one of its diameters.

From the nature of the case, this rotation must have been very slow indeed, probably one rotation in millions of years. If its diameter were 500 times that of Neptune's present orbit, it would require more than 36,000,000 years to make one revolution; even this velocity would slightly flatten it at the poles.

During these revolutions it was radiating heat, not only from its surface, but, on account of its extreme rarity,[1] from regions far below its surface. This radiation, combined with the gravitation of its parts, caused contraction; and this contraction, by well-known mechanical laws, increased the rate of rotation, and a consequent further flattening at the poles, while a correspondingly greater increase of density in the central parts took place.

This process continued till the rate of rotation of the bulging equatorial belt generated sufficient tangential force, by virtue of the rapid rotation of those particles, to counterbalance the gravitating force of the disk-like mass within, at which time further contraction of the outer edge of this nebulous belt, or beginning of a ring, ceased, except that infinitesimal portion due to resistance alone; for, at this time, each particle in this outer belt revolved in its own orbit around the central mass.

As radiation continued, contraction also continued, thereby conferring a planetary character on each particle of the successive layers of the equatorial ring of particles thus left out by the contracting nebulous spheroid.

Let us now confine our attention to this out-left ring, for *its* conduct

[1] It should be here remarked that the heat thus radiated from the nebula is not lost, but continues as wave-motion in the ether, until it is again converted into molecular motion in ponderable matter.

will show how planets and satellites are formed from rotating nebulous masses:

As radiation still continued, the repulsive force between the particles diminished, which allowed them to approach nearer to each other; and this tendency to agglomeration resulted in the formation of small centres of local attraction near the surface of the ring, where radiation was most rapid.

As condensation continued, new centres of local attraction were formed within, while the outer and older nodules continued to increase in size, and to coalesce into larger masses; till, finally, the outer edge of this ring had changed from an homogeneous and continuous nebulous disk to a multitude of nebulous planetoids of great volume, but of small mass; while the succeeding interior particles, as fast as they were left out by the contracting spheroid, were preparing to undergo a like change.

Now, as these planetoids have various periods of revolution, they will occasionally come into conjunction, and then, on account of the great volume and small mass of each, they should coalesce without crash; till, finally, some preponderating mass should collect all the little ones exterior to its orbit into itself, together with as many of those within its orbit as its gravitating force could control.

In like manner will all succeeding rings be collected into nebulous planets; and, if the masses of these planets be sufficiently large, they too, in a like manner, will develop nebulous secondaries after their own likeness, both in form and motion.

It is the satellites so formed of the out-left rings of the condensing nebulous planets in our system that have been under discussion in this paper.

That the nebulous planet thus formed will be given a motion of rotation in the same direction as that of its primary is due to the fact that the exterior planetoids have a greater *virtual velocity* than the interior ones have. This will become evident from the following considerations:

Let us consider, first, the effect produced on its rotation by one of the outer planetoids as it coalesces with this preponderating mass. As the two bodies approach conjunction, the small one will be drawn inward to meet the larger one, and this contraction of its orbit so increases its orbital velocity that, at the time of meeting, this velocity is greater than that of the controlling mass, and on striking it will give the latter an impulse to rotate in the direction of its orbital motion; while, on the other hand, one of the interior planetoids, by being drawn outward, will have its motion diminished to such a degree that, on meeting, it will give the larger one an impulse to rotate in the same direction as that which the outer one gave to it.

Now, if this nebulous globe be not disturbed by some *external* force, it will form the outer planet of the then future solar system.

This is the general rule for the formation of secondary bodies in all systems. In our system there seems to have been one exception to this general rule, viz., the asteroids. From some cause—most probably from external disturbance—this ring did not collect into a single mass, or, if so, was dashed into many fragments afterward by some meteoric or cometary body which, thrown out from some previously-formed nebula, had been wandering through space till it reached our system.

There are indications in other parts of the system of such external disturbances, notably in the satellitious system of Uranus.

From the manner in which the solar system has been formed, it seems most probable that all the bodies in it should both revolve and rotate in the same plane and direction that the sun does, had there been no external disturbance to prevent it.

Having examined the mode in which a planet is formed, and thus learned how a solar system may be formed out of nebulous matter, and having discovered that the system must be contracting into smaller dimensions from some sufficient cause, let us next inquire what consequences are most likely to follow the operation of such cause.

Consequences of Contraction.—It has been shown, by the foregoing investigation, that our system is expending its life-giving energy on some resisting medium which causes this contraction.

This, at first sight, seems saddening to contemplate; but there may be another point from which to view it. For, while it is seemingly wasting its life-giving power in this struggle with resistance, it may, in reality, be storing up a new supply of potential energy, by which a future activity may be insured. Or, in other words, it may be forming a new bud, which, when properly vivified by another one, may blossom forth with the most brilliant rainbow hues, and finally ripen into planetary fruit which shall become the happy home of future intelligent races.

Modus Operandi of Conservation.—It is well known that the stars are not fixed, but that they are moving in various directions with various velocities, relatively to our galaxy, at least.

Now, if the stars be moving, it is very probable that some of them are moving in such directions that they will finally meet, either in pairs or otherwise.

Let us direct our attention to two of them which are very like our star in mass and attendants, or we may suppose our sun to be one of them, and that they are so moving as to approach each other at the very slow rate of one mile a week; and let us further suppose that, before meeting, each will have arrived at that state of quiescence to which all systems are tending.

The object of assuming such slow original motion for the meeting bodies is to make a test case, as it were, in order to show clearly that the gravitative force of two such large bodies is sufficient to convert them both into a nebulous mass, besides throwing large portions of

this mass into the attracting spheres of surrounding stars, and thus beyond the possibility of return.

It may be proper, here, to point out the *modus operandi* by which such systems reach the state of quiescence alluded to above, which is, substantially, as follows:

The planets absorb their satellites by first converting them into fragmentary rings — as Saturn has already transformed two of his. These rings gradually approach the planets, till finally they fall upon their surfaces, and become part of them; while the planets themselves are approaching their primaries to succumb to a like fate.

Having absorbed their planetary attendants, and having cooled off so as to become cold, dark bodies, like the earth, they enter the sphere of each other's sensible attraction, and begin to approach with continually increasing velocity, till finally they meet, each arriving at the point of contact with a velocity of from 400 to 500 miles a second, depending on their mass and density.

Of the heat generated by such a collision, we can have no adequate conception. It may, however, be calculated, and written down in thermometric degrees;[1] still the figures are meaningless to us except as representing an inconceivable intensity of heat.

It may be stated as so many thousand times the heat generated by the explosion of an equal weight of gunpowder, still we are unable to form an idea of the unit of measure here given.

If the doctrine of the "correlation and conservation of forces" be true, then the heat thus generated, if it could all be applied in the form of moving force to these two bodies while yet intact, should be sufficient to throw them back again to the points at which their motions began to be accelerated, if there were no resistance; but, owing to the resistance met with, they will not rebound fully to those points.[2]

It will not, however, be expended in that manner, but in expanding the entire mass of these two globes into a thin, nebulous vapor; large portions of which, most probably, will be thrown out beyond the sphere of sensible attraction of that which remains, and into those of the surrounding stars.

This great probability will much resemble a certainty when we come to subject the question to the following speculative illustration:

[1] Assuming the average specific heat of cosmic matter to be one-fifth that of water, then the calculated temperature due to a velocity of 400 miles a second is equal to nearly 450,000,000° Fahr., or 250,000,000° Centigrade.

[2] It may be well to remark just here that the resistance here spoken of is assumed to be caused by the so-called ether of space, through which all bodies must move. Now, this resistance may be due to the inertia of the ether alone, in which case we must suppose that the ether is perfectly fluent, and receives a kind of mass-motion from the bodies moving through it. Or, on the other hand, we may conceive it to be a friction between the moving body and the ether. In this case the ether will be given a wave-motion of some kind, while the ponderable matter acquires a molecular motion. In either case there will be no motion lost.

If the entire nebulous mass could be preserved in the form of an expansible spherical shell, while the entire amount of heat-force should be acting upon its interior surface to force it outward, then, according to the above-named law of conservation, the entire mass would be thrown nearly to the limit of its sphere of sensible attraction; i. e., nearly to those points at which the motion of the two bodies began to be accelerated.

For the sake of convenient reference in the following difficult illustration, let us imagine the entire mass of expanding vapor to be divided into two equal parts, called respectively the *inner* mass and the *outer* mass; and let us imagine the heat-force to be divided into two equal parts also, called the *inner* force and the *outer* force.

Now, as these two forces are sufficient to drive these two masses very nearly to the aforesaid points of acceleration, and whereas only a part of the *inner force* can be expended in distributing the *inner mass* throughout the space surrounded by such limits, it follows that that part of the inner force so conserved will expend itself in helping the *outer force* to throw the *outer mass* beyond this sphere of sensible attraction, and, most probably, into those of the surrounding stars.

If such be the case, then some of these out-thrown masses may become cometary bodies and meteoric showers to the inhabitants of "other worlds than ours," besides forming abundant material for the "cosmical dust," so much discussed of late; and, possibly, some of the largest of these fragments may be able to produce asteroidal groups, in some ripening planetary system, by disrupting one of its planets while yet in the nebulous state. This seems to supply a deficiency in this hypothesis which has long been felt.

Density of the Newly-formed Nebula.—If, now, we fix our attention on the condition of this nebula at the moment when the explosive force had expended its last effort to throw these outside masses into surrounding space, we can readily see that it must have been of very nearly uniform density, in consequence of the tendency of the out-moving particles to continue their motions outward.

Confirmation.—It is very probable that many such explosions as that described above have been witnessed from our planet, and have been recorded in history as *temporary stars;* an interesting account of some of which may be found in Herschel's "Outlines of Astronomy."[1]

In May, 1866, such a phenomenon was observed in the Northern Crown. This collision, however, seems to have been, not with the star itself, but with one of its planets, or with some other dark body lying in that direction, which contained a large amount of water, the hydrogen of which, being dissociated from its oxygen, shone out with such brilliancy as to be seen at this distance.

That this was a *planetary* collision seems probable, from the fact that the star continued to shine with its normal light during the time

[1] Philadelphia edition, 1861, p. 472.

of, and after, this brilliant display of hydrogen, which is proved by the spectrum analyses of its light during that time.

The "new star" lately discovered in the constellation of Cygnus seems to be a complete confirmation of this theory.

A very interesting account of this star, by Richard A. Proctor, may be found in THE POPULAR SCIENCE MONTHLY for December, 1877. From this account the star seems to have passed through all the various changes which should naturally be expected from such a collision; first, a very great augmentation of light, with a continuous, rainbow-tinted spectrum arising from the intense pressure to which the rapidly-expanding mass of gas was at first subjected; gradually passing through various changes and gradations, till, finally, it took on the "spectrum of a true nebula," which should naturally occur after a large part of the intense heat of percussion had taken on the form of latent heat of expansion.

"As the stars are moving with various velocities in various directions," it may be asked, "What would be the consequences if two of them should enter each other's sphere of sensible attraction with very great velocities?"

In order to secure definite results, in replying to this question let us assume definite conditions:

Suppose them to be equal, and of such mass and density that each would approach the point of meeting with a velocity of 400 miles a second, by virtue of their mutual gravitation alone; and, further, that each one had an original velocity of 300 miles a second toward that point, when they entered each other's sphere of sensible attraction.

Now, they would meet, not with a velocity of 700 miles a second, as might, at first, be supposed, but with the velocity represented by $\sqrt{300^2 + 400^2}$, or 500 miles a second.

According to a previous mode of reasoning, the heat-force generated by such a collision should be sufficient to throw these two bodies outward beyond the possibility of return; therefore, the greater portion of the resulting nebulous mass would be thrown out with a corresponding velocity, and be distributed among the surrounding stars, leaving but a small portion of it to occupy the place of meeting; which, consequently, without further additions, would make but a small solar system.

CONCLUSION.—Let us now consider what would most likely be the result of such collisions, if the matter of the universe were of finite instead of infinite extent.

For this purpose we may assume the last-named pair of stars to constitute the entire amount of ponderable matter in the universe. It is supposed, then, that they are both moving directly toward the point of future meeting with a velocity of 300 miles a second, when each begins to be affected by the other's accelerating force; which, consequently, increases that velocity to 500 miles a second at the time of meeting.

It will readily be seen, from previous considerations, that large masses of the resulting nebula will be thrown out from the sphere of sensible attraction of the remaining mass, with velocities exceeding 300 miles a second, while other portions will emerge with less and less velocities, till finally some portions barely reach those limits.

The remaining nebula should then begin to contract, and might, possibly, form a small planetary system. Of the out-thrown masses, those which moved with the greatest velocity would retire to the greatest distances; but even they must finally stop, because they could not overcome perpetual resistance.

The resistance which these masses have to contend with is of two kinds: first, the feeble, insensible attraction of the remaining mass; second, the resistance of the ether.

The first diminishes with the square of the increasing distance, but is never reduced to absolute zero; the second, however, diminishes with the diminishing speed, and finally becomes nothing, at which time the body stops.

Now, would these farthest masses return? Most certainly they would; for no distance can be named so great that the force of gravity shall become absolutely nothing.

If it took millions of years for the most distant body to move one inch, after it had stopped it would eventually return to the central mass, which would itself finally become quiescent.

It will be readily seen that if any number of such bodies were put in motion in the boundless ether, they, too, would finally come to rest.

Another very well-known and much shorter path leads to this same conclusion; it is this:

If the ponderable moving matter of the universe be limited, then, by constant collision, its motion would all be converted into heat and light, and be radiated into the outer realms of space, never to return again, leaving all the ponderable matter to collect into one great mass, and to cool off to a state of perfect quiescence.

But, if matter be infinite, then there can be no "outer realms" into which this heat-force can radiate; consequently there will be no motion lost, and matter, since it has ever been moving, will continue in motion forever.

THE QUESTION OF PAIN IN HANGING.

By ROGER S. TRACY, M. D.

IN executions it is the custom to drop the condemned man from a height, or (as in New York) to jerk him up from the ground by the fall of a heavy weight, so that there is a powerful concussion of the brain to start with. It used to be a common belief that the necks of

criminals were broken by this means, and that the pressure of the fractured vertebræ on the spinal cord shortened the period of suffering. It is now known, however, that this rarely occurs, and the criminal dies of asphyxia or apoplexy, usually the former. In some persons, particularly in heavy or aged ones, the sharp and sudden violence of the shock is sufficient to burst some blood-vessel, and the gush of blood into the brain-substance renders the criminal immediately unconscious. But apoplexy rarely kills suddenly; even such persons really die of asphyxia. In feeble persons, the simple concussion of the brain may be sufficient to bring on insensibility, like a stunning blow on the head, without any visible lesion of the organ; so that, in a certain proportion of persons who are executed by authority of law, it is probable that insensibility is instantaneous.

Some men, however, with strong necks and coarse organizations, do not become unconscious from the shock of the fall, and suicides generally have no fall; so that, in such cases, death supervenes by asphyxia. But even here the process is not a simple one. It is complicated by a congestive apoplexy; i. e., such an overfilling of the blood-vessels of the brain as to produce unconsciousness by pressure on the brain-substance, but without the actual rupture of any artery. And in these cases, too, insensibility comes on so rapidly that death is really painless.

The fact that executed criminals suffer little has been known for a long time. Morgagni quotes Cesalpinus as saying that persons who have been hung and have not died have declared that "they were overcome with stupor at the instant of the tightening of the rope, to such a degree that they felt nothing." And he adds: "As for myself, I have learned from a sober and truthful man that a thief, whom the cord of the hangman had not killed, for the same reason that prevented the deaths of those individuals mentioned by Gardani in the Sepulcretum, told those who questioned him, that he at first saw sparks before his eyes, and soon after saw nothing and felt absolutely nothing, as if he had been asleep."

I once witnessed an execution at the Tombs, and observed the victim carefully, watch in hand. After the body fell to the length of the rope, it remained perfectly motionless, so far as I could see, and I was not more than twenty-five feet away. It swayed a little in the currents of air, and at the end of a minute and ten seconds there were three very slight drawings-up of the feet, and a peculiar quivering of the hands. Then all was still, and remained so until the body was taken down. In this case the neck was not broken, and death took place by asphyxia. It is probable that the shock of the fall caused an apoplexy, or the convulsions would have been more pronounced. It seemed evident to me at the time that the death of the victim was painless.

Devergie says: "A friend of Fodéré, after a long discussion with him on the phenomena of asphyxia, hung himself from his door, expecting

to be able at will to stop the experiment. Luckily, some one came into the room and rescued him. Chancellor Bacon has reported the case of a gentleman who took a fancy to find out for himself whether those who are hung suffer any pain. He put a cord around his neck, and hung himself, stepping off from a small bench on which he had been standing, and expecting to be able to mount it again when he wished. This was impossible for him on account of the loss of consciousness, which supervened immediately. The experiment would have had a tragic ending, if a friend had not by chance entered and released him.

In the *New Yorker Allgemeine Zeitung* for May 14, 1877, was the following item: "In the village of Brunswick, a bet was made, by one of three young fellows, drinking together, that he could hang for a certain number of minutes. A ladder was brought, put against the wall, a noose placed around his neck, and the end thrown over a round of the ladder. A second drew on the rope, while the third stood by, watch in hand. Just then in came a servant-girl, who saw the situation. At her exclamation that the man was blue in the face, the man with the watch said the time was not up. At her shrieks, however, others rushed in, and the cord was loosened. The poor fellow fell insensible to the ground, and was with the greatest difficulty resuscitated."

Although nothing is said in this account about the young man's sensations, it is likely that he became unconscious immediately; for, if he had felt the pangs of suffocation, as ordinarily understood, he would have certainly either grasped the ladder and relieved himself, or in some way indicated to his companions that he was suffering and wished to be let down.

Two remarkable examples are on record of persons who allowed themselves to be hung for the entertainment of an audience. An account of one of them is given in the *Lancet* of April 17, 1847. The man's real name was John Harnshaw, but he performed throughout England under the high-sounding professional title of Monsieur Gouffe. He was an athlete, and among other feats it was customary with him to exhibit the process of hanging. In this performance he relied for security on the strength of the muscles of the neck and throat. He had a rope with a fixed knot which could not slip, and passed both ends of the loop up behind one ear. The whole act was so adroitly managed that he prevented any pressure of the rope on the windpipe or the jugular veins, and could even sustain a weight of one hundred and fifty pounds in addition to that of his own body.

On three separate occasions Harnshaw mismanaged the rope, and became unconscious, being luckily rescued each time. Dr. Chowne, who writes the account, says very truly: "It cannot be doubted that, as far as sensation and consciousness are concerned, Harnshaw passed through the whole ordeal of dying; and, had he been permitted to remain hanging until actually dead, he would have passed out of existence without further consciousness."

Now, this man stated, not with particular reference to either accident, but as common to all, that "he could hardly recollect anything that happened to him in the rope;" that "he lost his senses all at once; the instant the rope got in the wrong place he felt as if he could not get his breath—as if some great weight were at his feet; could not move only to draw himself up; felt as if he wanted to loosen himself, but never thought of his hands." And he added: "You cannot move your arms or legs to save yourself; you cannot raise your arms; you cannot think." He did not see sparks or light, but had in his ears a rattling sound.

This account is an interesting one, because it shows the absence of physical suffering, even when consciousness is for a short time retained. The benumbing effect of the venous blood on the brain is well shown by his remarks on the confusion of thought and mental helplessness.

In the second instance, which has been fully recorded, the show-man was not so fortunate. He hung himself once too often, and the circumstances of his last exhibition were very singular. He was known as Scott, the American diver, and he, like Harnshaw, had many times hung himself before an audience with safety. The last time, however, the rope slipped in such a way as to compress the throat and bring on asphyxia. He hung thirteen minutes, the spectators thinking that he was prolonging the experiment for their gratification. When he was taken down he was dead. It is just to those who were looking on to state that they thought he was safe, because he was still, and did not raise his feet and stand upon the scaffold, which his legs actually touched. This case shows with peculiar force the insidious manner in which death comes on in asphyxia.

While death in such cases has been supposed to occur in consequence of the lack of air, there are good reasons for believing, as previously stated, that it may be largely if not mainly due to the congestion of the vessels of the brain. Fleischmann tried some experiments on himself with the object of throwing light on this question. He says: "If a person puts a cord around the neck between the hyoid bone and the chin, he can draw it tight at the back or side, without the respiration being sensibly interfered with, and can for a long time continue to inspire and expire naturally enough, because in this situation compression is not made on any part of the air-passages. Notwithstanding this, the face grows red, the eyes become a little glaring, the head becomes hot, there comes on a feeling of weight, dizziness, a sort of distress, and then all in an instant a hissing and roaring in the ears. This last symptom should be especially noticed, for it is time then to stop the experiment. I confess that a second time I should hardly dare to push it so far. The same symptoms follow the application of a cord to the larynx. It seems to me, though, that then they come on more promptly, and that the respiration is a little interfered with. I have been able to prolong the first experiment for more than two minutes,

while in the second trial a half-minute had barely passed when the noise in the ears and a peculiar sensation in the brain, difficult to describe, warned me to stop the experiment."

In the first experiment Fleischmann was on the very border of unconsciousness, and, as he himself says, did not stop a moment too soon. In the second, when the effects of asphyxia and cerebral congestion were combined, the result was reached much more rapidly.

Devergie states plainly, after considering all the facts, that hanging is a pleasant way of dying. His words are: "In suicide, at the moment of the application of the cord, or a few moments after, a feeling of pleasure manifests itself; then supervenes disordered vision; bluish flames appear before the eyes, and the loss of consciousness soon follows."

All the evidence goes to show that death by hanging is painless, and there is positively no fact or well-founded opinion to the contrary. If this be the case, then, what is the explanation of it? Simply this: That in every form of strangulation the blood-vessels of the neck are compressed, as well as the air-passages. A large part of the blood is returned from the head by the external jugular veins, which are very near the surface, and in which the current can be checked by slight pressure. Most of the blood from the brain itself comes back through the internal jugulars, which lie near, but a little outside of, the carotid arteries. The walls of veins are lax and yielding, so as to be easily compressed, while those of the arteries are firm and elastic, and it requires considerable force to approximate them. Pressure, then, which is sufficient to close the jugular veins only crowds the carotids a little farther inward, and the blood is still poured through them into the brain, whence it cannot escape. When this pumping process is going on at the rate of seventy strokes a minute, it is easy to understand how the engorgement of the vessels of the brain, in a very brief time, reaches a degree which causes insensibility. To explain why this congestion causes unconsciousness would involve a technical discussion which would here be out of place. It must suffice to say that it does; so that, as the cerebral congestion in a hanged person brings on insensibility within a minute, while the physical agony of suffocation does not begin until later, it follows that the victim does not feel any of the pangs of asphyxia. He first becomes insensible, with accompanying pleasurable feelings, from cerebral congestion, and then is choked to death while unconscious.

Drowning and hanging, then, are painless modes of dying, because the asphyxia which causes death is complicated by other circumstances which render the dying man so soon unconscious that the pangs of suffocation are unfelt. And the insensibility which results from hanging is so insidious and painless in its approach, that experiments on the subject are very dangerous for any one to make alone. It is probable that many persons, who are supposed to have committed suicide in this way,

had really no intention of bringing about their own death. Some have been led, like the two gentlemen mentioned by Morgagni, to try the experiment out of curiosity. Others may have done it out of pique. It is not impossible, nor perhaps improbable, that high-spirited boys or girls, after a degrading punishment, should rush off, as we read of their doing, and hang themselves. The child puts a cord around his neck, and steps off from a chair, expecting to be followed, found choking, and released, by the anxious parents. If he is not followed and his absence not noticed, nothing can be easier for him than to step up on the chair again, loosen the rope, and no one will ever know of his folly. In the first case he would obtain his childish revenge for the wrong he had received, and in the second case he would lose nothing, for he is his only accomplice. But the laws of Nature are too stern. He experiences the fate of poor Scott, above related. Utterly ignorant of his danger, and intending only a prank of childish folly, he steps from his chair into eternity. Such a possibility should make us charitable, and in cases of suicide by hanging lead us to remember that, although the case may be evidently one of suicide, and the hanging plainly intentional, nevertheless the death may have been undesired and unlooked for.

THE RADICAL FALLACY OF MATERIALISM.

By R. G. ECCLES, Esq.

NOT many years ago the manifestations of energy were looked upon as mere conditions of matter. When a moving body came to rest, it was thought that the motion was obliterated from the universe, and, when a body at rest was put in motion, it was supposed to be a creation. The motion was looked upon as a *mere state* that had arisen and ceased. To-day, in the light of the new doctrine of the correlation and conservation of forces, the old notions are inconceivable, because of the rise of a new element of thought, namely, that force is caused by energy. Motion to us is the effect of a real though immaterial existence, called force or energy, acting upon matter. This energy persists in spite of every effort to destroy it. It is seen to leap from matter to matter as motion, when passing through a row of elastic collision-balls, as each successively gives up its energy to the next. Energy being seen to travel from matter to matter, persisting in one piece after eliminating the other, we are compelled to look upon it as having a real existence of its own. It may change its form many times, but through all the mutations there remains the identical energy. After repeatedly following it through such changes, we conclude that the universe contains a fixed quantity, never had more, and never

can have less. While the form of this energy changes, the substance endures forever. In this respect it resembles matter. The forms of both matter and energy are fleeting, but the invisible substance endures. By their interactions they incessantly alter each other. The forms of energy determine the forms of matter, and the forms of matter determine the forms of energy. In this respect their interdependence is mutual. The form of matter determines whether energy shall be moulded into heat, light, sound, magnetism, chemical affinity, cohesion, or molar motion. The mode and amount of energy determine whether matter will be solid, liquid, or gas, opaque or transparent, colored or colorless, etc. As all matter must have some form, so all energy must have some mode.

Whatever form matter may assume, that form is built from the elements of form of which matter can never divest itself. While matter and energy have independent substantive existences, form has no existence apart from the matter with which it is found. One piece of matter cannot give up its form to another, as one collision-ball can give its energy to another. The failure to see this truth has led to serious mistakes among psychologists. The elements of form belonging to one piece of matter may be put together in the same order as found in another piece, so that the identical form may appear to have been transmitted. The elements of form belonging to matter may imitate or mimic each other, but this does not constitute identity. The two words R′O′S′E′, ROSE, may look alike, but each has its own form. If we transpose them as entire words, ROSE, R′O′S′E, they have not given up their own forms. If we transpose them letter by letter, as beneath, each still retains its own form, and has not appropriated that of its neighbor:

First change.....	RO′S′E′	R′OSE
Second "	ROS′E′	R′O′SE
Third "	ROSE′	R′O′S′E
Fourth "	ROSE	R′O′S′E′

When transposed as entire words, the entire forms are transposed at once, and, when transposed as letters, the forms are transposed in their elements. At the base of the left thumb of the writer there is a scar, made during boyhood. All the tissue has probably been removed several times, as in the transposition of the letters of our word ROSE; but because the material that supplied the waste has been the same in kind, and because these elements of form have been put up in the original order at every change, a scar is there to-day like the one of years ago. For convenience' sake we call it the same scar, yet it is no more the same than are our two words, when transposed, identical. By one set of the elements of form imitating another an illusion is established that makes it appear as if the identical form was transmitted from one mass of matter to another, just as the identical energy is

transmitted. In this way are organized forms maintained during the lapse of years, despite the waste continually going on.

Now that the self-existence of energy has been substantiated, and motion is no longer considered merely a condition or state of matter in the old sense, the creation and annihilation theory is being shifted to consciousness or the ego feeling. This feeling is looked upon as a product of a certain mode of motion brought about by a certain form of matter, or it is said to be one side of energy. But few pause to consider what such expressions imply. If consciousness is a product of organization, then the proper amount, quality, and arrangement, of matter and motion constitute the ego. Let us consider this. If we put inactive matter together in any form we choose, the only thing we can conceive of its having is that form. Add energy to such an arrangement of matter, and the only conceivable result will be some mode of motion which the mode of arrangement directed. Whether we arrange atoms, molecules, or masses, in simple or complex order, the addition of energy will only give a mode of energy. Matter can direct energy, but we cannot conceive of its turning it into something that is not energy. We cannot conceive of a motion being a passion or sensation. No element of kinship can be detected between a kind of motion and love or hate. Conceive of any mode, speed, or direction of motion you choose, and they will never even suggest the possibility of their creating thought, will, hate, avarice, love, ambition, color, sound, taste, odor, or any other sensation. We can perceive that these are all forms of the one ego feeling, but that that could ever arise merely from a mode of motion is absolutely unthinkable. We can conceive of feeling COMING IN when certain forms of matter and modes of energy are present, but no alternative theory can for a moment be entertained. It must either *come in* under favorable circumstances or be their product. The law of excluded middle forbids a third possibility. The first of the only two alternatives is conceivable, the second inconceivable. If we here apply Mr. Herbert Spencer's test of truth, "the inconceivability of the opposite," we must admit that consciousness possesses an independent existence of its own. We can conceive of no form of matter and energy being the ego feeling. As it is absolutely impossible to think of any form of motion arising in matter without energy entering from some source, so it is equally as impossible to conceive of consciousness arising in any form of matter or motion without conceiving that a substance of consciousness was infused at some stage. We may, by refusing to think, give an indorsement to the verbal expression, and so deceive ourselves by imagining we believe it. Every proof that can be given of a substance of matter or energy will be equally telling when turned on consciousness. It is just as impossible to conceive of the substance of matter being energy or consciousness, of the substance of energy being matter or consciousness, as of the substance of consciousness being matter and energy. If we demand

clear ideas, there is no other alternative than to view the three as distinct but incomprehensible existences. Consciousness *reveals itself* through matter and energy. Energy *reveals itself* through matter and consciousness. Matter *reveals itself* through energy and consciousness. Take away any one of the three and the other would be unknown. How could we know matter but for vibrations? How could we know energy but for matter? How could we know consciousness but for sensations induced by energy? No one of these can be known without the other. Mr. Fiske's world of pure consciousness is as inconceivable as a world of motion where there is nothing to move. We do not and cannot know what the substance of matter is. We only know the sensations it produces in us through its vibrations. The theory that assumes the existence of matter is accepted because no other will explain our experiences. We meet precisely the same difficulties when we assert that matter is the result of the combination of consciousness and energy, or that energy is the result of the combination of consciousness and matter, as when we declare that consciousness is the result of matter and energy. Let any person attempt to conceive of whatever pair he may choose of this trinity producing the third and he will find every effort in vain. Take them pair by pair, and the difficulty will be the same in every pair, thus revealing a common guarantee for the identity of each as distinct from the other. Men talk glibly of the production of consciousness by organization, but the words are mere meaningless jargon. When we see what is meant by such an expression, we shall learn that the idea has equal lucidity with that of a round square. Evolution deals only with the forms of this trinity. Forms evolve, but the substances are eternal. As dissolution follows evolution, the forms of each are resolved into their elements, to be refashioned again into new forms. Matter may form a tree, a crystal, a man, or a world; energy may form heat, light, electricity, or sound; and consciousness may be fashioned into memory, intellect, color, or emotion. These are the transient manifestations of the enduring verities.

Men in prescientific times lost sight of the persistence of matter because they looked upon the form as the reality. When fuel ceased to show a solid, compact form after combustion, they thought it was annihilated. Up to a later date they looked upon the form of energy as the reality, and when that form vanished they were content to declare it as swept from the universe. When motion changed to heat, they thought it was annihilated. The form being destroyed, as that form was mistaken for the reality, they thought the reality had vanished from existence. With broader and more enlightened views this method of reasoning on energy and matter became obsolete, but it still continues to be applied to consciousness. Intellect, memory, or emotion, being put forward for consciousness, how can we refrain from thinking that it goes when these go? As energy determines the form of

matter, and matter determines the form of energy, so consciousness determines their form and they determine the form of consciousness. It is well known to the most superficial observer that the body affects the mind, and the mind affects the body. A man with toothache, drunk, or in a fever, in in a bad state to think. When mentally depressed or in great excitement, the body is affected, and disease or even death may be induced by a fright. A blow on the head may destroy memory for all past events or only part of them. How easy for men, who look upon memory as the substance of consciousness, to declare that that blow on the head suspended consciousness, because memory was a blank for some minutes or hours after it! As well might we talk of energy being suspended from the time motion ceases to be seen as such in the magneto-electric machine till it reappears as motion again in the electro-magnetic machine. While the body rests in sleep, the forms of consciousness are, to all intents and purposes, still, and we say the sleeper is unconscious. Give the alarm of fire, and see how quickly the so-called unconscious man will be aroused. Did he first hear that call and then awake, or did he awake first and then hear the call? If he heard the call before awakening, then consciousness was awake to hear it while the body slumbered. If he awoke before he heard the call, then the call did not awaken him. No matter how deep the slumber of the body, something remains awake to catch the signals from without.

Every form of consciousness being built of that form we call the ego feeling, or feeling of individual identity, that feeling may be expected to persist wherever consciousness persists. As the connections of matter and energy, so far as form is concerned, are perfectly continuous and complete in every form that each assumes, so the connections of mind and body from beginning to end will be found just as perfect and thorough-going throughout. Given the form of matter, and the form of energy can be at once inferred. The forms of matter, motion, and consciousness, have from beginning to end the most intimate relations with each other. Each moulds the other into the form in which it appears, and it would, indeed, be remarkable from this view of the case if our experiences of the power of bodily condition over mind were not as they are. Nerve-waves are not sensations. The nerve-matter is there and the wave and sensation are there, but by no effort of thought can we conceive them as less than three. Whether any one of these can exist independent of the others cannot be known. We know matter as possessing energy, and when the philosophic mind attempts to divest it of all energy it melts into inconceivability. In attempting to separate energy from matter we are foiled. We know consciousness as connected with matter through energy. When we attempt to remove consciousness in thought from this relationship, it slides out of thought completely. In an ultimate analysis each of the three appears with a substantive basis of its own, but the natures of

these bases are totally beyond the range of knowledge. Our persisting symbol of matter is extension; of energy, motion; and of consciousness, feeling. We cannot reduce our conception of matter to unextended points of force, nor can we think of either energy or consciousness as latent. The words but cover a vacuity of thought.

Any system of philosophy that denies a substantive basis for the ego feeling, exclusive of the bases of matter and energy, virtually denies the existence of knowledge of every kind, and so stamps itself as false. Our only assurance of the existence of anything outside of ourselves is the effect produced on consciousness. If the perceiving consciousness is not real, how can we assert that the perceived matter is? Action and reaction are equal and opposite. If consciousness has not persistence and permanence of its own, how can it gauge persistence and permanence in matter and energy? But for consciousness we could know of the existence of nothing else. Is it logical to claim that our conclusions are permanent and real, while asserting that our premises are unsubstantial and unreal? Yet this is what every materialist is compelled to do. No theories of "double-faced entities," "results of organization," or "remodeled definitions of matter and energy," can ever be conceived to explain the facts.

One of the strongest proofs of the independent existence of the soul is seen in the fact that at no two consecutive moments of our lives does the ego feeling rest upon the same matter or energy. The systems of waves within my brain will all have radiated away many times before this paragraph is completed. The matter giving out, the energy will pass away as waste, and the arteries bring back a new supply. For days, weeks, months, and years, matter and energy will thus pass while the identical consciousness will persist, and can be traced through every change precisely as energy can be traced from matter to matter. To say that energy is a two-sided entity, one side of which constitutes sensation, is against the facts. The energy my body has to-day is not that of yesterday. Yesterday's energy has all radiated away and carried both its sides with it; but consciousness—the same consciousness—is still here. The closeness of analogy between the conduct of energy toward matter and of consciousness toward energy is remarkable. Let M′ M″ M‴ M⁗ represent four pieces of elastic matter, and *e* a quantity of energy. By collision, *e* will travel from matter to matter thus:

First position	*e*′ M″ M‴ M⁗
Second "	M′ *e*″ M‴ M⁗
Third "	M′ M″ *e*‴ M⁗
Fourth "	M′ M″ M‴ *e*⁗

As *e* travels from M to M it can be no part of M, so must have a distinct existence of its own. Now let E′ E″ E‴ E⁗ represent the brain-waves of as many consecutive moments and *c* our conscious identity.

As the waves follow each other in the order of time, *c* will travel from one to the other thus :

First moment	E*c*′ E″ E‴ E⁗
Second "	E′ E*c*″ E‴ E⁗
Third "	E′ E″ E*c*‴ E⁗
Fourth "	E′ E″ E‴ E*c*⁗

As *c* travels from E to E it can be no part of E, and must have a distinct existence of its own. The deportment of matter, energy, and consciousness, toward each other, is much like that of the three letters M, E, C, toward each other in our illustration. Let any person try to make these three letters one, as the ancients did by the entities for which they stand, or but two as the moderns do by them, and precisely the same muddle of inconceivability will arise with the letters as has arisen with the things. The materialist is not satisfied with trying to make himself and others believe that matter and energy produce consciousness, but he must believe that, no matter how often he changes his matter and energy, every new supply will produce the identical consciousness the old one did. If we wish a note of a certain pitch and timbre, we must have matter in a certain form; and, if we wish a sensation of a certain kind and quality, we must have energy of a certain mode. The tuning-fork or violin-string is not the energy of the vibrations, nor is the wave of motion the consciousness of sensation. It is necessary that the brain of to-day be like that of to-morrow if I get the same *form* of consciousness from it each time, but the brain is not the consciousness. To the form of brain there is not continuation of identity. The brain of to-day mimics that of days ago, because the elements of form are put together in the same order. The consciousness that appears is the identical consciousness, no matter what the form nor how much energy has escaped. If we declare matter and energy to be eternal, then we must declare the same of consciousness. We know matter as atomic, energy as rhythmic, and consciousness as individualized.

SKETCH OF PROFESSOR DU BOIS-REYMOND.

THE name of Du Bois-Reymond stands high among that group of illustrious scientific men of whom Germany may well be proud. He is known throughout the scientific world for his masterly researches in experimental physiology, having, while yet a young man, made a series of brilliant discoveries in electro-physiology, which at once placed him at the head of that delicate and important branch of investigation.

But the customary channels of international scientific communica-

tion have hitherto been so narrow that the public has not yet been able to recognize his greatness as a thinker on high questions of scientific philosophy. We do not say that Prof. Du Bois-Reymond is more than a scientist, for, in our view, that is a term of great breadth, but we do say that he is much more than a scientific specialist. He is a comprehensive and cultivated thinker. For largeness, originality, and independence of view, for depth of analysis and thoroughness of erudition, and for clearness, vividness, and vigor of style, he has no superior among his distinguished German contemporaries. His celebrated address on "The Limits of our Knowledge of Nature," which attracted great attention in Europe, was first presented to the English-speaking public in THE POPULAR SCIENCE MONTHLY for May, 1874; and we now offer another of his productions to our readers, which is the subject of comment elsewhere. Prof. Du Bois-Reymond is in the vigorous maturity of his life, and, although he has done a great deal of valuable work, much more is still expected from him. We hope in due time to bring before the American public some other of his able productions that are suited to popular appreciation.

EMIL DU BOIS-REYMOND was born in Berlin, November 7, 1818. His father, a native of Neufchâtel, in Switzerland, had in his youth been a watch-maker, but subsequently entered upon a literary and official career in Berlin. Du Bois-Reymond's mother was descended from the Huguenots, who were driven from their country by Louis XIV. Among his maternal ancestors we must not omit to mention the celebrated artist and engraver, Daniel Chodowiecki, called by some the Hogarth of Germany.

After the fashion prevalent in Germany, Du Bois-Reymond first attended a primary school, then the Collége Français of his native town; but, when he was about eleven years old, his parents went to live several years in Switzerland, and during this period he was a pupil of the College of Neufchâtel. The French language, therefore, was from his childhood as familiar to him as German.

Later on, we again find Du Bois-Reymond in Berlin; and at the age of eighteen he became a student at the university of that town. It is said that, like many others who afterward distinguished themselves in natural science, he first devoted himself to theological studies, and that, during a session, he regularly attended Neander's lectures on ecclesiastical history. Chancing, however, to enter the lecture-room of the celebrated chemist Mitscherlich, he felt irresistibly drawn toward his true vocation. He now studied chemistry, natural philosophy, mathematics, and during the summer of 1838, which he spent at Bonn, on the Rhine, also geology, without any very definite aim.

This was eventually pointed out to him by a friend, the late Dr. Edward Hallmann, who, with greater scientific experience, convinced him that, of all the branches of science, the study of animated Nature affords the highest interest and includes the deepest problems, and

that medicine is the proper road to that goal. A medical student, then, Du Bois-Reymond became, and as such, a pupil, and soon after an assistant of the great anatomist and physiologist, John Müller.

The connection with Müller decided, as it were, his fate. Humboldt at that time received a copy of Matteucci's "Essai sur les Phénomènes électriques des Animaux," and communicated it to Müller. Müller, knowing that Du Bois-Reymond possessed a share of physical and mathematical knowledge very unusual in a student of physiology, thought him qualified to take in hand the investigation of animal electricity, in which Matteucci had made but a poor advance since Nobili's discovery of the so-called current of the frog. Thus it happened that, in the spring of 1841, Du Bois-Reymond undertook to elucidate the problem proposed to science by Nobili, and for nearly forty years he has not ceased to work upon this subject, which, in his hands, and those of his numerous pupils, has marvelously expanded, so as to become one of the most important branches of physiology.

Du Bois-Reymond, after having in 1842 printed a short account of his first results, went on working patiently for seven years, and then published his celebrated book, "Researches in Animal Electricity" (Berlin, 2 vols., 1848–'49). This work, besides a complete history of what had previously been done upon the subject, contains an immense number of experiments, made after methods, and with the aid of apparatus, for the most part entirely new, invented by Du Bois-Reymond himself. In substance, the book is devoted to the exposition of his discoveries of the muscular and of the nervous current, of their law, and of the variations they undergo when the muscles and nerves are thrown into action.

To understand the importance of these discoveries, it must be borne in mind that, long before Du Bois-Reymond, in fact since the middle of last century, innumerable attempts had been made to observe electrical phenomena during the contraction of the muscle. They had all failed. Du Bois-Reymond, at the outset, perceived that one of the reasons of these failures was the transient nature of the contraction, and he invented the method of tetanizing the muscles in order to increase the duration of the contraction, and thereby facilitate the observation of what takes place in that state. He was thus fortunate enough to detect electrical phenomena concomitant with the act of contraction, and he even taught how to deflect the magnetic needle of the galvanometer by the voluntary contraction of the muscles in living man, or, as it were, by our will. The correctness of these facts having been doubted by MM. Despretz and Becquerel, of the Académie des Sciences, Du Bois-Reymond, in 1850, went to Paris with his apparatus, and triumphantly proved the truth of his statements.

As to the nerve, up to the date of Du Bois-Reymond's researches, no material change had ever been observed during its activity. In this case, too, a great many fruitless attempts had been made to discover

some electrical phenomenon connected with that state. Du Bois-Reymond constructed with his own hands a galvanometer of 24,000 coils, by far the most sensitive ever made up to that time, and by its means succeeded in disclosing an electrical phenomenon in the tetanized nerve, which, for certain reasons we cannot here explain, he styled the *negative variation* of the nerve-current. In point of fact, he transmuted into a deflection of the galvanometer that molecular change in the nerve which, had it reached the muscles, would have convulsed them, and which, had it reached the brain, would have caused pain. He also decided the long-vexed question whether the nervous fibres conduct only in one direction, or in both, by showing that the negative variation is equally well transmitted in a motor nerve in the centripetal, and in a sensitive nerve in the centrifugal direction.

Soon after the publication of his "Researches," Du Bois-Reymond, then thirty years old, was elected a member of the Royal Academy of Sciences of Berlin. As already stated, he has ever since pursued and extended his investigations; but it is impossible, in the compass of this brief notice, more fully to detail their results. Moreover, those of our readers who may feel interested in the subject will find a conscientious *exposé* of most of Du Bois-Reymond's papers in the book of one of our countrymen, of whose talents science has been robbed by a premature death—Mr. Charles E. Morgan, author of "Electro-Physiology and Therapeutics" (New York, William Wood & Co., 1868). These results will also be found in Prof. Rosenthal's German treatise on the "Physiology of Muscles and Nerves," contributed to the "International Scientific Series," and soon to be published in this country. Du Bois-Reymond's papers have also been collected in two volumes, under the title "Gesammelte Abhandlungen zur allgemeinen Muskel- und Nervenphysik" (Leipsic, Veit & Co., 1875–'77).

Several of Du Bois-Reymond's papers bear merely upon electricity, without reference to physiology. We will only mention his experimental and theoretical researches on the aperiodic state of the magnetic needle induced, under certain circumstances, by high dampening powers; these researches are of the greatest practical importance. Du Bois-Reymond also showed, contrary to what Berzelius and Liebig had stated, that the substance of muscles when at rest is neutral, or slightly alkaline, becoming acid only after death, when *rigor mortis* sets in, but that also in the act of contraction acid is evolved.

In 1858 John Müller died, and Du Bois-Reymond was appointed in his place Professor of Physiology in ordinary, and Director of the Physiological Laboratory at the University of Berlin. In this position he has exercised a considerable influence on the progress of physiological study in Germany. Many of the professors of physiology at the other German universities have been his pupils; and this influence has been increased by the friendship which has always connected him closely with his fellow-students Brücke, Helmholtz, and Ludwig—all of them physi-

ologists as averse as he to the doctrine of vital forces, and as eager to reduce physiology to applied chemistry, natural philosophy, and mathematics. He was also one of the founders of the Physical Society of Berlin, whose reports on the progress of natural philosophy are well known to every lover of science.

In 1867 Du Bois-Reymond was elected one of the secretaries of the Academy of Sciences of Berlin, and this office afforded him the opportunity of displaying, in the public addresses which it imposes on him to deliver, a new side of his genius. He generally chooses some subject in the history of science on which he knows how to throw a new and brilliant light, as in his essays on Voltaire and on Lamettrie, which have not yet appeared in English.

Du Bois-Reymond is considered one of the most successful teachers of the university, and the public lectures, in which he yearly alternates between "Anthropology" and "Some Recent Advances in Physical Science," are often dangerously crowded. Having been a good deal in England, and married a lady of English education, he commands the English language sufficiently to lecture in it. The late Dr. Bence Jones, of London, who had formed an intimate friendship with Du Bois-Reymond, and had published an abstract of his discoveries ("On Animal Electricity," etc., London, Churchill, 1852), engaged him repeatedly to lecture in the Royal Institution, where Dr. Faraday, and other eminent Englishmen of science, were much interested in his experiments. In 1855, in the theatre of the Royal Institution, he showed, and described in the *Philosophical Magazine*, the beautiful method of rendering the deflection of a galvanometer visible by a beam of light reflected from a mirror attached to the needle; of which method Sir William Thomson subsequently availed himself for the readings of the Atlantic Telegraph so successfully that it has ever since been attributed to that able physicist.

Du Bois-Reymond is a member of the Academies of Vienna, Munich, and Rome, and an associate of the Royal Societies of London, Göttingen, Upsala, etc. He has been employed these last three or four years in erecting in Berlin, at the expense of the German Government, the largest and finest physiological laboratory in existence. His new lecture-room is said to be the most beautiful and best appointed in the world.

EDITOR'S TABLE.

PROFESSOR JOSEPH HENRY.

IN the death of Prof. Henry, Secretary of the Smithsonian Institution, which occurred May 13th, American science has met with an irreparable loss. Little needs to be said in eulogy of a character so widely and familiarly known, and so profoundly respected and admired, as this venerable *savant*. In Volume II. of THE POPULAR SCIENCE MONTHLY will be found an excellent portrait of Prof. Henry, with a sketch of his life, and an enumeration of his most important scientific labors; but there are two or three features of his career that are entitled to special recognition, now that he has passed away.

It is very well understood in the scientific world that, more than any other man, Prof. Joseph Henry is the scientific founder of the system of modern telegraphy, and this honor ought to be equally conceded to him by the general public. His earliest discoveries and his most important scientific work were in the field of electro-magnetic research, entered upon within a very few years after Oersted had announced the discovery of the relations of electricity and magnetism. Prof. Henry worked out experimentally, and by the most elaborate investigations, those laws and principles of electro-magnetic action which made the telegraph possible; and not only this, but he actually constructed and operated an electric telegraph years before Prof. Morse turned his attention to the subject. The great contrivance was of course bound to come, but no consideration of this kind should be permitted to detract in the slightest degree from the honor of those by whom it came. The scientific discoverer is entitled at any rate to have his work recognized, especially as he rarely gets anything else. It is the man who runs in upon his discoveries and applies them and brings them into notice that is usually credited in the popular estimation with all the honor. In this case, Morse has appropriated the glory that fairly belongs to Henry. Morse originated nothing by the current telegraphic alphabet—that is, the combinations of taps and clicks of the instrument, by which letters are denoted. Electricity had long been looked to as an agent for the transmission of intelligence. Many experiments had been made from the time of Franklin to secure this object, but none of them had succeeded. Various contrivances had met more recently with partial success, but Prof. Henry's sounder of 1830 has gradually displaced, and has now almost entirely superseded, all other methods of electric signaling. Mr. E. N. Dickerson, in tracing out the history of telegraphic invention, after stating the merits of various previous contrivances, thus refers to Henry's work:

"Then came Prof. Henry, who, in 1830, deduced from the hypothesis of Ampère—that magnetism was the circulation of electricity at right angles to the line connecting the poles of the magnet—the invention now known as the compound electro-magnet. In that year he constructed an electro-magnet that would sustain 1,000 pounds weight; and he answered the demonstration of Barlow, and proved that the electro-magnetic telegraph was possible. In the same year he set up an electro-magnetic telegraph at Albany, over a line of a mile and a half in length, using what is now known as the 'polarized relay,' between the poles of which a magnetic armature vibrated upon a hinge, as the current of electricity was reversed—the end of the armature striking a sounder, and transmitting the intelligence by sound. This was the first electro-magnetic telegraph (I use the popular phrase) ever made; and it was the first one possible

to be made, because, until Prof. Henry's electro-magnet was invented, it was an impossibility. This electro-magnetic telephone, made by Prof. Henry in 1830, is the thing in universal use to-day. It goes by the erroneous name of the 'Morse telegraph;' and it will be in use till the end of time. The thing was perfect as it came from the hand of its author, and has never been improved from that day to this as a sounding telegraph."

Having immortalized himself by these brilliant researches of the laboratory, Prof. Henry was called into a more conspicuous sphere of action as the organizer and administrator of a great public enterprise of national scope in connection with the progress of science. John Smithson, an English chemist and physicist, and member of the Royal Society, had left upward of half a million dollars as a trust to the American Government, to be used for "the increase and diffusion of knowledge among men." How this language was to be construed and how the money was to be expended were open questions. The Washington politicians were in favor of spending it on buildings, libraries, and museums to be established at the national capital, and the whole fund would probably have been buried and lost in this way, but for the influence of Prof. Henry. He was appointed, in 1846, as secretary and principal executive officer of the Institution, and at once applied all his energies to rescue the fund from the misdirection that had been given to it, and to devise more efficient means of obtaining the comprehensive object to which it was devoted. As Smithson was a man of science, and an original investigator of that "natural knowledge" which the Royal Society of Great Britain, of which he was a fellow, was founded to promote, Prof. Henry fairly and justly assumed that the intention of the donor was the increase and diffusion of scientific knowledge—increase and augmentation by research and organized systems of observation, and diffusion by means of extended publication. Henry's policy, therefore, was to diminish expenditures upon buildings, libraries, museums, and art-galleries, that the money might be devoted to wider and more legitimate purposes. He took the ground that the Institution ought to do nothing which can be equally well done by any organization or instrumentality already in action. He accordingly drew up a scheme of operations which provided for extensive researches especially in the fields of ethnology and of meteorology. He had for many years five hundred meteorological observers scattered over the continent, accumulating data designed to elucidate the laws which govern the phenomena of the weather. This branch of work, begun on so thorough a scale by the Smithsonian Institution, has developed into the Signal Service and Weather Bureau in Washington, now so important to the agriculture and commerce of the country. In the department of publications the public has been furnished with the "Smithsonian Contributions to Knowledge," now consisting of many large quarto volumes, all valuable as positive additions to the sum of existing knowledge. Besides these, the Institution has put forth the "Smithsonian Miscellaneous Collections," and "Annual Reports," all of which are intrinsically valuable for the information they contain, and are very widely circulated through the country. Prof. Henry's plan also comprehended an extensive system of exchanges of works, proceedings, and reports, between the literary and scientific associations of the Old and New World. All these features of Prof. Henry's broad and liberal scheme of administering the Smithsonian trust have been carried out vigorously, and with a degree of success that has commanded universal approval. An administration of thirty years has settled the policy of the Institution, and will undoubtedly shape its future, and it is very doubtful if there was another man in the United States that could have done

this work with such conspicuous success as the distinguished man to whom it was so fortunately intrusted.

It may be added that, in a business point of view, the establishment has been managed with great skill and efficiency. The amount of money received from Smithson, in 1838, was $515,000, to which was added in 1865 a residuary legacy of Smithson amounting to $26,000; and, notwithstanding that a large portion of the fund has been absorbed in building, all the plans of Prof. Henry have been carried out, and the fund now available exceeds $700,000.

MAGNIFYING SOUND.

How scientific discoveries run in groups, one thing suggesting another so quickly as to make an epoch, is just now illustrated anew in the field of acoustics, and with the usual result of rival claims and disputed priority. Following the telephone and growing out of it comes another remarkable revelation, that minute sounds may be magnified to the ear as minute objects are magnified by lenses to the eye.

The telephone, in transmitting sound, greatly reduces or minifies it, and it therefore became a problem for experimenters to find out how sounds can be transmitted with the least loss of volume and intensity. Mr. Thomas A. Edison early attacked this problem with his usual assiduity and fertile inventiveness. Operating upon many hundred substances of diverse qualities and in varying conditions to test their sonorous capacities under electrical influence, he found that carbon possesses this singular property in a very remarkable degree. He found, moreover, that the effect varies with the pressure upon the carbon, and, what is more astonishing still, that it varies so greatly with the small differences of pressure produced by the passage of sound-waves as to alter the flow of the electrical current. More than a year ago he embodied this principle in the "carbon telephone," by which the capacity of the instrument was greatly augmented.

But now Prof. D. E. Hughes, already well known as the inventor of the type-printing apparatus that bears his name, comes forward with an arrangement involving the same property of the same substance, but developing almost incredible effects. He claims to have reached these results in his own way, as follows: Following a hint of Sir William Thomson in regard to the molecular change and conductivity of wires under mechanical strain, he inserted a stretched and strained wire in his telephonic circuit. But no effect was produced until it broke, when a sound was given out so curious and marked that Prof. Hughes followed it up, by pressing the broken ends together, when the new effect was faintly reproduced. Following this suggestion, he introduced other pieces so as to have broken or imperfect connections, when the faint sounds were improved. Iron nails or a steel watch-chain also answered the purpose.

Prof. Hughes says he found the same property in porous charcoal, and that it was heightened by infiltrating the carbon with metallic mercury. The part introduced into the circuit Prof. Hughes calls the "transmitter," and the arrangement which he recently exhibited to the Royal Society consists of a glass tube two inches long, and one-fourth inch in diameter, filled with a series of plugs of mercurialized carbon, the end-plugs being attached to the wires of the circuit. He uses a small three-celled galvanic battery to furnish the current, and, with the transmitter introduced, sounds otherwise perfectly inaudible by the ear are not only heard, but are conveyed to great distances by the telephone. The surprising thing is that when these pieces of carbon barely touch each other the electric current

will not pass; but when the molecules of those adjacent pieces are agitated by sound-waves they transmit electricity freely. The same effect is produced by light when the metal selenium is exposed to light, and its electrical conductivity is unequally affected by the different rays of the spectrum. Prof. Hughes calls his invention the *microphone*, and it has this peculiarity, that the sounds are taken up directly by the "transmitter."

The London *Telegraph* thus refers to the results of Prof. Hughes's experiments before the Royal Society: "Inserting a 'transmitter' in his circuit, an absolutely amazing sensitiveness to sound, as well as power of conveying it with the utmost fidelity, was displayed by the apparatus. A touch of the finger on the vibrating plate of the telephone was conducted to the speaking end in volume of vibration like the rustle of a forest; the stroking of a camel's-hair brush on a card was magnified into the sound of a loud whisper; the beating of a pulse or the tick of a watch was found to pass with perfect clearness through a resistance representing a hundred miles of space; and, when a fly happened to walk over the plate, the tramp of its feet was most distinctly caught, like that of some six-legged horse trotting, and it was, moreover, heard to trumpet from its raised proboscis like an elephant in an Indian jungle. Sounds, in fact, totally inaudible before to human ears, were arrested and reported by this simple and accidental expedient of interrupting the electrical circuit with a finely-divided conducting material."

CATHOLICISM AND ETERNAL PUNISHMENT.

Under the title of "Hell and Science," a writer in the *Catholic World* for June makes an elaborate reply to our recent comments on the doctrine of future punishment. He is especially indignant, as might be expected, at our remark that there has been a "rapid liberalization of theological opinion" on this subject. He says that "the doctrine of hell is not a theological opinion but an inspired dogma," which, of course, can be neither liberalized nor got rid of in any other way. In speaking of the altered theological tone upon this subject, we of course referred to what currently passes under the name of theology, but our reviewer avers that we were utterly wrong in the application of the word. This is his case:

> "Theology is essentially based on authority; hence theology has no existence in the Protestant sects, whose very reason of being is a contemptuous disregard of authority, and the assumed right of private interpretation. Now, all those who ventured to argue against the existence of eternal punishment belonged to Protestant sects; and, therefore, their 'liberal view' of the subject does not constitute 'theological opinion.' Protestants may, indeed, assume the title of 'divines;' but the title is not the thing. There is no real theology outside of the Catholic Church. When Catholic divines shall discuss the existence of hell as a free theological opinion —which, of course, will never happen—then only Prof. Youmans will be welcome to say that there has been a liberalizing of theological opinion."

We freely admit that there is great shrewdness in this policy of the Catholics, by which so effective an instrument of domination as the fear of hell is placed beyond examination on the part of the followers of that faith. By shutting off the right of private judgment on dogmas sanctioned by authority, they no doubt get rid of the ferment of discussion and diversity of opinion which, among Protestants, follows the exercise of the right of private interpretation. The writer in the *Catholic World* identifies liberalism with Protestantism, and recognizes that among Protestant sects the notion of hell is dying out. He thus concedes that liberalism leads to this result,

which is all that we claimed, but he denies that modern liberalism exerts its baneful and pestilent influence within the precincts of his church, or that there is any change going on within it respecting the dogma of hell. Yet of this we are not so certain. The liberalizing influences of the age are subtile, diffusive, encroaching, and all-pervading. Such influences have been growing for centuries, and the Catholic Church has by no means escaped them in times past. They have convulsed it and rent it, and are now agitating it profoundly. What warrant have we that these patent disturbing agencies are to be inoperative in the future? Our reviewer, indeed, informs us that there is no change in his church in regard to eternal damnation. To our remark that the doctrine of hell is being refined away, he replies that "the literal lake of fire and brimstone is preached even now all over the earth;" and, to our assertion that the notion is growing obsolete, he rejoins that "two hundred millions of Catholics believe the doctrine as a cardinal tenet of the Church."

But it is important not to be misled here. In what sense are these two hundred million Catholics said to "believe" in the doctrine of hell? Belief implies evidence, and is founded upon it; how, then, can men believe that of which they are never permitted to think in connection with evidence? They may *assent* to the doctrine, or *accept* it under the influence of early teaching, or terror, or the coercion of spiritual authority; but the rational act of belief implies the liberty of doubt, the freedom of inquiry, and a judgment resting upon proof. How can this be possible with a dogma upon which men are forbidden to exercise their minds, and are not even permitted to class as a "theological opinion?" We know what the Catholics profess; it is quite another thing to know what they really believe. Of course, the term belief in the theological world is used in a very loose way, and is made to cover whatever is contained in an accepted creed. But in aiming to get at the real state of mind, which is the object here, it is necessary to discriminate between views that are rationally entertained on some claim of reasonable grounds and dogmas that are blindly held under theological dictation. Our reviewer admits that there is a growing liberalization, that it is the very essence of Protestantism, and that it is inroading upon the old doctrine of future everlasting punishment; and it is perfectly well known that the Catholic Church is deeply troubled about the encroachments of the so-called "spirit of the age," which it denounces in the most solemn manner. Can there be any doubt that the invading spirit of liberalism will affect Catholic minds in the same way that it has Protestant minds. If not, where is the danger, and what the excuse, for the anxiety of the Church? Under the external exertion of a rigorous ecclesiastical system, uniformity of profession can be secured; but of what avail is the force of authority in the case, or where does it take effect if not in resisting private reason, and substituting profession for real belief? There may be two hundred million Catholics who still accept the belief in hell, but it is not possible that all of them, in this age, can be in such a complete state of mental paralysis as not to reflect upon the grounds of their belief, and to hold the opinion with more or less of the same reservations that are exercised by other classes of Christian believers.

Prof. Du Bois-Reymond, of Berlin, several months ago gave an address before a scientific association at Cologne, which was recently published in an amplified form by the author. We procured an early copy for translation, and sent the English proof to the author

for revision. Meantime the discourse had quickly passed through several German editions, revised by the author, so that the address, the first part of which is now presented to the readers of THE POPULAR SCIENCE MONTHLY, embodies his latest corrections and emendations.

We were especially desirous of having a complete and authorized edition of this elaborate address, both from the profound interest of the topic, and because of certain special views developed by the author which are likely to attract much attention. It is an historical disquisition on the course of civilization in relation to science, and sketches the various stages and phases of man's progress in culture with masterly compression and a vivid eloquence, which will enchain all thoughtful readers. How the Greeks and Romans failed to seize upon the scientific aspects of Nature, and the calamities to the world that followed from that deficiency in their mental cultivation, are problems that Prof. Du Bois-Reymond handles in a fresh and original way. Equally interesting is his view, that for science the world is indebted to Christianity, which, by its monotheism and the intolerance entailed by sincere monotheistic belief, gave a new earnestness and intensity to the human mind, that impelled it to a deeper research into causes, and to a more thorough exploration of the order and method of Nature.

But Prof. Du Bois-Reymond's thesis does not stop with speculative inquiries; it extends to important practical results. The history of the rise of science, as discussed in the first part of his essay herewith printed, has a weighty interest on its own account, but its claim upon our consideration is redoubled from the import of the conclusions arrived at in the sequel. The history of science and civilization derives its highest significance from the bearing it has on the policy of modern culture. The organization or reorganization of education, the formation of national systems of instruction, and the modification and extension of the old colleges and universities, are undoubtedly the gravest questions that the present age has before it, and it is with these that the eminent German professor has grappled in this discussion. They, moreover, have become in a literal sense world-questions; and so intimate are now the intellectual reactions among distant and different countries that the higher policy of education is nothing less than international. Prof. Du Bois-Reymond is keenly alive to these broader aspects of the subject, and the views he presents will have a peculiar interest for readers in this country, because he recognizes not only that America is exerting an influence upon the higher education of Europe, but because he considers that influence as by no means of an elevating or ennobling character—as something rather that the intellect of Europe must put forth its utmost power to withstand.

WE continue the important series of papers, by Prof. Alexander Bain, on "Education as a Science." He is now dealing with its psychological basis, and with those laws of mind—in the present paper, of sensibility and emotion—which govern the processes of culture and the arts of the teacher. In his great work on the "Emotions and the Will," Prof. Bain has carefully worked out the principles which are here briefly reëxpounded in their bearing upon educational practice. How to get command of the motors of intellectual cultivation—the emotions—is one of the teacher's most urgent problems. What emotions will hinder the work of culture, and what will promote it, how they are to be quickened and how restrained, under what circumstances they shall be appealed to, and how they come in play in different stages of development and in relation to dif-

ferent objects of study—all these practical questions turn upon a knowledge of psychology, which, if we are ever to have a science of education, must be so sufficient that it can be applied to individual cases. Prof. Bain is clearing the ground for a thorough-going discussion of that element of culture which has been more misunderstood and perverted than any other—the subject of discipline.

LITERARY NOTICES.

SYNOPTICAL FLORA OF NORTH AMERICA. By ASA GRAY, LL. D. Vol. II., Part I., Gamopetalæ after Compositæ. New York: Ivison, Blakeman, Taylor & Co. 8vo. Pp. 402. Price, $6.00.

WE can in no way do such excellent justice to this comprehensive and elaborate work, as by quoting, in full, the able review of it that appeared in the *New York Tribune*:

"The 'Flora of North America,' by Drs. John Torrey and Asa Gray, was commenced in 1838, and appeared in numbers, at convenient intervals, until 1840, when, having reached, in the accepted arrangement of orders, to the end of Compositæ, its publication ceased. So valuable was this 'Flora' to the working botanists, that its discontinuance was a source of great disappointment; and those who were not aware of the reasons which made its intermissions almost imperative were not a little impatient. To those best advised, the discontinuance of the work was known to be really in the interest of American botany. The acquisition of Texas and of new territory at the close of the war with Mexico essentially changed our botanical as it did our geographical area. Up to that time, our knowledge of the far Northwest, the far West, and the Pacific coast, was mainly due to the labors of European explorers, to which were added the results of the journeys of Nuttall, Wyeth, Long, and a few others, but nothing like a general exploration had been made of those vast fields which have since yielded such rich botanical harvests. The two journeys of Fremont, the forced march to the Pacific on the line of the Gila, by Emory, with the volunteer expeditions of Lindheimer, Wislicenus, Fendler, Wright, and some others, resulted in such a wealth of new material, opening, in some cases, an entirely new flora, that it at once became evident to its authors that the 'Flora of North America' could not yet be written with any approach to completeness. These explorations indicated that the number of genera in the families, and the number of species in the genera, already published in the 'Flora,' were in many cases doubled, and it became evident that the authors must either continue a work which would be unsatisfactory when finished, or suspend it for a time, and devote themselves to the elaboration of the rapidly-accumulating new material, which would otherwise pass into other hands. They wisely adopted the latter course, a decision which proved all the more judicious when the survey of the Mexican boundary and the surveys of numerous routes for a Pacific railroad added most essentially to the already rich collections, and opened to botanical exploration such a breadth of territory that but few important localities were left unvisited. Besides these Government expeditions, and nearly contemporaneous with the later of them, came the private explorations of Parry, Hall, and Harbour, and others, while the rapid settlement of mining and other localities brought out a number of local collectors, who made important additions to the rapidly accumulating treasures. The State Geological Survey of California, and the survey under Mr. Clarence King under the fortieth parallel—thanks to Sereno Watson's energy and perseverance—also yielded important botanical results. The time has now arrived when the 'Flora of North America' may be written with the hope of presenting a fairly complete record. Of course new species and new genera are yet to be discovered, but no such bonanza of botanical riches as the past thirty years have developed can be looked for in the future, and our present knowledge may properly be embodied in a work which will serve as a standard, around which the clustering of future accessions will be an easy matter.

"One of the illustrious botanists, whose name appeared as joint author of the earlier 'Flora,' and which will ever be identified with North American botany, has passed away; but the results of Dr. Torrey's many years of labor since the first 'Flora' was discontinued will appear in the new work, the pages of which will show how industriously he labored during that long interval.

"We have said that the present is a most fitting time for making a 'Flora of North America;' it is so, not only in the fullness of materials, but especially so that its author is in the fullness of his industrious and useful life. Prepared, as no other can be, by years of study of our plants from every part of the country, and also by the experiences of extended field-observations on two journeys to the Pacific coast, our first botanist presents this, which we may regard as his crowning work. It is fortunate that, just at this time, those eminent botanists Bentham and Hooker have presented in their 'Genera Plantarum' a complete revision of the genera, made, so far as American genera are concerned, in full sympathy and correspondence with Dr. Gray. While, in the 'Flora,' Dr. Gray may not adopt all the views of these gentlemen, it is not the less gratifying to American botanists to know that the genera, so recently elaborated by three such botanists as Gray, Bentham, and Hooker, are likely to be accepted as established for a long while to come.

"With this brief statement of the 'conditions precedent' to the 'Flora of North America,' which have more interest for the botanist than the general reader, we glance at the work itself.

"The present (first in order of appearance, but not in botanical sequence) is the first part of the second volume, taking up the orders where the former flora left off. It begins with the *Goodeniaceæ*, and ends with the *Plantaginaceæ*. Two more parts will be required to complete the second volume; the one to immediately follow this will be devoted to the Apetalous and Gymnospermous Exogens, and the final part will contain the Monocotyledonous plants and the Vascular Cryptogamia. The first volume will include the Polypetalous orders, and the Gamopetalæ to the end of Compositæ. It is expected that each volume will contain about twelve hundred pages.

"The first thing which will strike the working botanist on opening its pages is the excellent mechanical arrangement of the flora, and especially its compactness as compared with the former 'Flora of North America.' This is attained in part by conciseness of description, but mainly by the omission of extended synonymy. This lack of synonyms is happily supplied by the contemporaneous publication, by the Smithsonian Institution, of the 'Bibliographical Index to North American Botany,' by that most industrious of botanical workers, Mr. Sereno Watson, of the Herbarium of Harvard College. This work gives full references for each species, and, while it is of the greatest importance that its matter should be recorded, it is not of a kind needed by the majority of those who will use the 'Flora,' and its preservation in a separate work is most fortunate, especially as it allows the 'Flora' to be much more compact.

"It is hardly necessary at this day to say anything in praise of Dr. Gray as a systematic botanist. Those familiar with his other works will be prepared for the admirable method which characterizes this; the same conciseness of description, the keen perception which seizes upon and points out the distinctive characters, and the same broad views of the range of genera and species which mark his other works, will be found here. Yet we venture to say that this work will add to his reputation with those who can understand the difficulties of his task, and can appreciate the completeness with which it is executed. Almost any one, familiar with botanical terms, can so describe a species that it may be identified by another. It is the treatment of large genera that puts the systematic botanist to the test. The generic description should give characters which cover every species, while the specific description should not repeat any of the generic characters—a matter simple enough, but its non-observance is very tiresome, even in the works of botanists of distinction. For convenience, large families have in many works an artificial key to the genera, and large genera a similar key to the species. This is well enough in elementary works. In the present 'Flora' the large genera are grouped in subgenera, which, if sufficiently important, have distinctive names; these subgenera are subdivided into sections and subsections, each briefly defined by prominent characters common to all the species it includes. For example, in 'The Flora' (which will soon become its accepted and familiar title), in the now large genus *Mimulus*, we have the primary divisions or subgenera: 1. *Eunanus;* 2. *Diplacus;* 3. *Eumimulus;* 4. *Mimuloides;* all except No. 3 having been ranked by one botanist or another as genera. Some of these subgenera include a dozen or more species, which are grouped in subdivisions of two to five, by characters common to all. It is in such grouping that the systematic botanist shows his tact, and we feel sure that those who make use of 'The Flora' will find that the eye of the author has lost none of its early keenness, and that his perception of the essential characters is as acute as ever.

"While we welcome this installment of the 'Flora of North America' as an important event in the history of American botany, and announce its appearance with no little national pride, we utter the wish of every American botanist when we express the hope that its author may be spared to complete the work so admirably begun."

AMERICAN JOURNAL OF MATHEMATICS, PURE AND APPLIED. Editor-in-Chief, J. J. SYLVESTER, LL. D., F. R. S.; Associate Editor-in-Charge, WILLIAM E. STORY, Ph. D., with the coöperation of BENJAMIN PEIRCE, LL. D., F. R. S., SIMON NEWCOMB, LL. D., F. R. S., and H. A. ROWLAND, C. E. Published under the Auspices of the Johns Hopkins University. Vol. I., No. 1. Pp. 104. Baltimore: printed by John Murphy & Co. Price, $5 per year; $1.50 single number.

THIS periodical is to appear quarterly, or as nearly so as may be found practicable, each volume of four numbers containing about 384 quarto pages. It is designed chiefly as a medium of communication between American mathematicians, and has for its primary object the publication of original mathematical investigations. "In addition to this, from time to time concise abstracts will be inserted of subjects to which special interest may attach or which have been developed in memoirs, difficult of access to American students. Critical and bibliographical notices and reviews of the most important recent mathematical publications, American and foreign, will also form part of the plan."

"The editors believe it will materially aid in fostering the study of mathematical science throughout this continent, and they feel it their duty to state that any good which may arise from it will be in a great

measure due to the enlightened liberality of the trustees of the Johns Hopkins University, who have prompted the undertaking, and guaranteed a considerable portion of the pecuniary risk attendant upon it."

It is needless to say that this periodical is in no sense popular, and is wholly unintelligible to non-mathematical readers. But it deserves to be sustained in the interest of higher American scholarship, and public-spirited men, who can make it of no use to themselves, may nevertheless promote a good work by subscribing for it, and presenting it to libraries, educational institutions, and mathematical students, who are unable to pay for it themselves.

TROPICAL NATURE, AND OTHER ESSAYS. By ALFRED R. WALLACE. New York: Macmillan & Co. Pp. 356. Price, $3.50.

MR. WALLACE'S new volume consists of some eight essays, of which the first four only can be strictly considered as coming within the scope of his principal title. Two of the chapters have already appeared in *Macmillan's Magazine;* one has been published in the *Fortnightly Review*, and one was originally delivered as a presidential address to the Biological Section of the British Association in 1876. Hence the whole work comprises a slightly heterogeneous mixture, and the first three essays have rather the appearance of an afterthought, inserted for the purpose of giving a consistent *raison d'être* to the publication, than that of a complete and consecutive treatise. But, of course, Mr. Wallace can never be otherwise than ingenious and interesting, nor does the present volume form any exception to the general excellence of his compositions.

The author sets out by stating that, while the luxuriance and beauty of tropical Nature are a well-worn theme, which has often suffered from the undue exaggeration of its exponents, no attempt has yet been made to give a broad sketch of those phenomena which are *essentially* tropical, and which mark the chief differences between equatorial and temperate climates. This desideratum he seeks to supply, from the exceptional experience of a long residence in the hottest regions of the Eastern and the Western Hemisphere alike. In pursuance of the design thus laid down, the first essay treats of "The Climate and Physical Aspects of the Equatorial Zone," both as regards their actual phenomena and the causes which lead to their production. Though possessing, of course, little absolute novelty, the facts are well arranged, and so displayed or illustrated as to bring the salient points of tropical meteorology in a very vivid manner before the untraveled student. The second essay, on "Equatorial Vegetation," contains an admirable sketch of the tropical flora, viewed in its *ensemble*, besides a vigorous exposition of the common but fallacious belief that large and brilliant flowers are exceptionally frequent in hot climates. Mr. Wallace succeeds in giving a clear and sufficient notion of the richness and profusion of vegetable growth without rousing any suspicion of that false theatrical glamour which ordinary writers have cast around the subject. The third essay deals with "Animal Life in the Tropical Forests," dwelling especially upon the *Lepidoptera* and *Hymenoptera* among insects; the parrots, pigeons, and picariæ among birds; and the monkeys and bats among mammalia—all of which form the peculiarly equatorial types of their several classes.

But it is with the fourth essay, on "Humming-Birds," reprinted from the *Fortnightly Review*, that the real interest of the work begins. Mr. Wallace gives a short sketch of the structure and habits of these birds, and then takes the species which inhabit the island of Juan Fernandez as illustrations of the action of variation and natural selection. In a bold and successful *a priori* reconstruction of their history, amply justified by the incidental verifications which crop out during the course of the argument, he traces their origin, with great probability, to two separate accidental migrations, under stress of weather, from the opposite coast of Chili. At the same time he shows the probable causes of the resulting variations, and starts a theory of organic coloration, which is more fully treated in the two succeeding essays. He then points out the strong structural resemblances between swifts and humming-birds, while demolishing the supposed connection between the latter and their Eastern representatives, the sun-birds—a connection based entirely upon adaptive and functional pe-

culiarities, necessarily common to two families whose modes of life are so exactly analogous. No better practical specimen of the new biological methods than that afforded by this essay could possibly come into the hands of readers with good common-sense and little special scientific knowledge.

The fifth and sixth essays, on "The Colors of Animals and Sexual Selection," and on "The Colors of Plants and the Origin of the Color-Sense," lead us at once into the region of controversy. They appeared originally in *Macmillan's Magazine*, but they have since been enriched by numerous additions and alterations, in accordance with suggestions from Mr. Darwin or other correspondents. In the first of these two papers, Mr. Wallace brings a powerful battery to bear against the accepted doctrine of sexual selection, and it must be confessed not without effect in shaking, if not in demolishing, that stronghold of Darwinism. He contends that color is a natural product of organic forms, which may be checked or intensified by natural selection, but whose occurrence is quite normal, and so stands in need of no separate explanation. All colors in animals may be classified under four heads—protective colors, warning colors, sexual colors, and typical colors. The two former do not now require further definition; but sexual differences of hue he attributes not to conscious selection of mates, the occurrence of which is emphatically doubted, but to a special necessity for concealment in one or other sex; as, for example, in the incubating females of birds, or in the males among those species in which that sex undertakes the duty of hatching. This explanation would refer the variety in coloring to natural selection alone, acting unequally upon the several sexes, and so causing a partial suppression of bright tints. The vast majority of animal markings Mr. Wallace attributes to typical coloring; that is to say, a conventional or meaningless distribution of pigment, serving mainly for purposes of recognition between the members of the same species. Though it would be rash too readily to accept or reject these careful and well-reasoned conclusions, it seems probable that an intermediate belief will ultimately prevail. Certainly, Mr. Wallace has shown beyond a doubt that natural selection will adequately and simply account for many curious phenomena which Mr. Darwin believed to be due to conscious preference. The partial elimination of this markedly Lamarckian element in the theory of descent cannot but be regarded as a distinct gain, though few readers will be inclined entirely to agree with the author in his total rejection of sexual selection.

The sixth essay applies the same general principles to the colors of plants, and contains some interesting speculations on the beauty of Alpine flowers, and on the difference between succulent fruits and nuts. It also touches briefly on the question of the development in insects and vertebrates of a faculty for the perception of colors, with remarks upon the theories lately advanced by Geiger, Magnus, and Gladstone. This and the succeeding paper are chiefly noticeable for their exposition of the author's opinions upon certain ultimate teleological questions. In his book upon the Malay Archipelago, Mr. Wallace advocated the belief that all the beauty of the external world was due to natural causes, without any divine afterthought as to its effects upon the human mind. But, since that time, the implications contained in the doctrine of evolution seem to have clashed with earlier prejudices, and driven this otherwise acute and vigorous thinker into a coquetry with so-called spiritualism, which has vitiated much of his later work. In the present volume he suggests that the colors of the organic world, though developed by ordinary laws, may have been specially directed by some superior agency with reference to the final enjoyment of their beauty by man. In short, he inclines to the purely gratuitous supposition that butterflies, birds, and flowers, acquired brilliant tints in the Secondary and Tertiary periods, partly in order that men might look upon them in the Quaternary. And the essay which we are now considering concludes with the ominous sentence, "The emotions excited by color and by music, alike, seem to rise above the level of a world developed on purely utilitarian principles." It is greatly to be regretted that the joint discoverer of the theory of natural selection should allow himself to make use of such painfully dyslogistic and unscientific language.

The seventh essay, the presidential address, bears the title of "By-paths in the Do-

main of Biology," and consists of two totally distinct portions. The first comprises an excellent monograph, in the author's happiest manner, on the influence of locality upon coloration, and brings together a number of valuable facts upon which future theory may be founded when the time becomes ripe. But the second part is a criticism upon the views generally entertained by the scientific world on the origin and antiquity of man: and the conclusion toward which (though nowhere clearly stated) it implicitly points is the author's favorite dogma that the human intellect has *not* been evolved by the same natural causes which have developed the human organism. As elsewhere, Mr. Wallace seems disposed to believe in a special and solitary miracle, whereby a new form of consciousness was suddenly and supernaturally foisted upon the human brain. Readers of Mr. Herbert Spencer's "Psychology" will scarcely incline to accept this incongruous and ill-digested hypothesis.

The eighth essay treats of the "Distribution of Animals as indicating Geographical Changes." The author here treads again on firmer and more familiar ground, and his conclusions carry considerable weight.

As a whole, the work, in spite of many crudities and a marked increase of the teleological bias, is fully worthy of Mr. Wallace's deservedly high reputation. Every page is laden with fruitful and suggestive ideas; while the same charming and natural style as ever carries on the reader with unflagging interest from the first page to the last. The book is one which will arouse much controversy upon special questions; but it cannot fail to extort praise for its width of view, its subtilty, its firm grasp of principles, and its perfect mastery of facts. It should find a place at once in the library of every thinking naturalist and every general reader who feels an interest in the great and absorbing problem of organic evolution.

THE SUGAR-BEET IN NORTH CAROLINA. By A. R. LEDOUX. Raleigh: *Farmer and Mechanic* print. Pp. 50.

WE have in this pamphlet an account of certain experiments in the cultivation of sugar-beets in North Carolina, together with a statement of the present condition of the sugar-beet industry in the United States. Further, there is a synopsis of the results obtained in beet-culture in Europe. The information here contained would doubtless be of interest to farmers everywhere, though it is addressed primarily to those of North Carolina, the author being chemist to the Department of Agriculture of that State.

A CRITICAL HISTORY OF THE DOCTRINE OF A FUTURE LIFE. By WILLIAM ROUNSEVILLE ALGER. Tenth edition, with Six New Chapters, and a Complete Bibliography of the Subject comprising 4,977 Books relating to the Nature, Origin, and Destiny of the Soul. The Titles classified and arranged chronologically, with Notes and Indexes of Authors and Subjects. By EZRA ABBOTT, Librarian of Harvard College. New York: W. J. Widdleton. 1878. Pp. 913. Price $3.50.

THE new and enlarged edition of this erudite and exhaustive work is now especially timely and opportune, as the doctrine of punishment in a future life is undergoing so thorough and searching a scrutiny. Dr. Alger's book is a perfect treasury of history, analysis, and criticism, in relation to the course of human speculation and of religious belief respecting man's future state. We published some strictures not long since, on the doctrine of eternal punishment, and aimed to show that the belief in hell is confined to no religion and no period, but in a great variety of forms is an ancient and universal belief. Our assertion has been feebly contradicted by an eminent Catholic authority, to whom we refer the encyclopedic work now before us. The added chapters in the tenth edition, it may be stated, greatly amplify and strengthen the proofs of the position we assumed—proofs that were already as overwhelming and demonstrative as anything to be found in the history of human opinion. Dr. Alger has contributed a standard and most valuable work to the literature of this interesting subject, which will be made doubly useful to all scholars and inquiring readers by the comprehensive and careful bibliography which has been appended to it, and we are glad to notice that the liberal publisher has issued the book in a handsome form and at a price so extremely low that it may take its place in every private library.

INSANITY IN ANCIENT AND MODERN LIFE. With Chapters on its Prevention. By DANIEL HACK TUKE, M. D. New York: Macmillan & Co. Pp. 226. Price, $1.75.

THIS is a popular volume by an authority upon the subject which it treats, and which is becoming constantly of greater general interest. Formerly belonging to the medical profession, questions of insanity are now engaging the attention of legislators, educators, and sociologists. The historical chapters are curious and interesting, and those on the management necessary for preventing attacks of mental disorder are instructive and important.

THE BOY ENGINEERS. WHAT THEY DID AND HOW THEY DID IT. By Rev. J. LUKIN. New York: G. P. Putnam's Sons. Pp. 344. Price, $1.75.

THE design of the author of this book is to inspire boys with an interest in engineering and mechanical work, and to develop any latent capacity they may possess in that direction. The work is written in the form of a simple autobiography, wherein a boy is supposed to chronicle his own and his brother's labors as amateur mechanicians and engineers. Still the volume contains something more than a record of boy engineering, though at the same time, as the author remarks, there is no work described in it which a persevering and industrious lad might not accomplish. The "Boy Engineers" cannot fail to exert a healthy influence on its youthful readers.

INTERCULTURAL TILLAGE. By Dr. E. LEWIS STURTEVANT. Reprinted from the "Report of the Secretary of the Connecticut State Board of Agriculture." Pp. 42.

BY "Intercultural tillage," Dr. Sturtevant means tilling, stirring the soil while the plant is growing. The value of intercultural tillage has long been understood, but not so its *rationale*. Hoeing and ploughing serve to remove weeds, also to loosen the soil, and both of these things favor the growth of the plant. But Dr. Sturtevant finds that the main advantage derived from intercultural tillage is the *pruning of the roots*, causing them to branch out abundantly in every direction, in search of food. He cites sundry experiments made by himself, which go to show that this is the true theory of "intercultural tillage." The pamphlet is well worthy of the attention of farmers.

JOURNAL OF THE ACADEMY OF NATURAL SCIENCES OF PHILADELPHIA. New Series. Vol. VIII., Part III. Pp. 127, with 14 Plates.

Two paleontological memoirs are contained in this number of the *Journal*, viz., a "Description of Vertebrate Remains, chiefly from the Phosphate Beds of South Carolina," by Prof. Joseph Leidy, and a "Description of a Collection of Fossils made by Dr. Antonio Raimondi in Peru," by William M. Gabb. The vertebrate remains determined by Prof. Leidy embrace species of *Equus*, *Hipparion*, *Elephas*, *Mastodon*, *Manatus*, *Cetacea*, Fishes, and other land and marine animals. Dr. Raimondi's collection represents the labors of eighteen years, and was described in part by Prof. Leidy, some years ago, in the *American Journal of Conchology*. The work is now complete, and there is appended a pretty full "Bibliography of South American Paleontology," together with a "Synopsis of South American Paleontology."

CHEMICAL EXPERIMENTATION: Being a Hand-book of Lecture Experiments in Inorganic Chemistry. Systematically arranged for the Use of Lecturers and Teachers in Chemistry, as well as for Students in Normal Schools and Colleges, and for Private Study. By SAMUEL P. SADTLER, Ph. D., Assistant Professor of Chemistry in the University of Pennsylvania. Louisville: J. P. Morton & Co. Pp. 225. Price, $2.50.

THIS is a hand-book of chemical experiments, and makes no claim to be a chemical text-book. Following the order of Barker's "College Chemistry," the work is designed to give full instructions for the illustration of chemical lectures. A large variety of experiments are fully described, from which teachers may draw for such as are thought best for class-room illustration. It is an excellent compilation for an important purpose, and cannot fail to be useful in institutions which have ample command of chemical apparatus. The illustrations are large, numerous, and admirably executed.

AT THE COURT OF KING EDWIN: A Drama. By WILLIAM LEIGHTON, Jr. Philadelphia: J. B. Lippincott & Co. Pp. 157. Price, $1.25.

THIS is said to be considerable of a poem, and we know nothing to the contrary.

The author wrote "The Sons of Godwin," which was published a fortnight before Tennyson's "Harold," and the *Louisville Courier-Journal* said: "It appears at the same time with Tennyson's poem, upon the same theme, and does not suffer by comparison with it; it has more dramatic fire, and moves with brisker step, and has as sweet songs in it, and as much poetry." If all this be true, then there must undoubtedly be excellence in Mr. Leighton's present work.

A NEW AND IMPORTANT COOK-BOOK.—D. Appleton & Co. will shortly publish the "Hand-Book of the National Training-School of Cookery" at South Kensington, London. These practical "lessons in cookery" are the result of years of careful experience in training pupils of all grades and capacities in the art of preparing food in the best manner. The English press are unanimous in declaring that, in point of simplicity, clearness, and fullness of directions, in presupposing complete ignorance on the part of the learner, and adopting a method that is easy to follow, this book is greatly superior to any work upon the subject hitherto produced.

PUBLICATIONS RECEIVED.

Manual of the Vertebrates of the Northern United States. By D. S. Jordan, Ph. D., M. D. Second edition, revised and enlarged. Chicago: Jansen, McClurg & Co. Pp. 406. $2.50.

Machine Construction. By E. Tomkins. Vol. I., Text, pp. 368, $1.50; Vol. II., Plates (XLVIII.), $4.50. New York: Putnams.

Report of the United States Fish Commissioner (1875, 1876). Washington: Government Printing-Office. Pp. 1024.

Science Lectures at South Kensington. Vol. I. London and New York: Macmillan. Pp. 290. $1.75.

Current Discussion. Vol. II., Questions of Belief. New York: Putnams. Pp. 370.

Art Hand-books—Sketching from Nature. Pp. 74.—Landscape Painting. Pp. 74. New York: Putnams. 50 cents each.

Encyclopædia of Chemistry. (Parts 26 to 30 inclusive.) Philadelphia: Lippincott.

Iron-Works of the United States. Pp. 136. Report of the Iron and Steel Association. Pp. 89. Philadelphia: The Association.

Flowering Plants and Higher Cryptogams growing without Cultivation near Yale College. New Haven: The Berzelius Society. Pp. 71.

Pacific Coast Minerals, Ores, etc., in the Paris Exposition. San Francisco: E. Borqui & Co. print. Pp. 90.

Abstract of Statement of the Board appointed to test Iron, Steel, and other Metals. Salem: Printed at the Salem *Press*. Pp. 20.

Metric System of Weights and Measures. Philadelphia: The Engineers' Club. Pp. 5.

Mental and Moral Science. By H. Howard, M. D. From *Canada Medical Journal*. Pp. 15.

The Kirografer and Stenografer. Quarterly. Amherst, Mass.: J. B. & E. G. Smith. Pp. 32. $1 per annum.

Report on the State Asylum for Insane Criminals. Auburn, N. Y.: Moses print. Pp. 23.

Remarkable Case of Morphine Tolerance. By J. L. Little, M. D. From *American Journal of Obstetrics*. Pp. 6.

Vital Magnetism in the Treatment of Disease. By F. T. Parson. Brooklyn: The Author. Pp. 32.

Report of the Commissioner of Agriculture. Raleigh, N. C.: *Farmer and Mechanic* print. Pp. 18.

Perception of Color. By G. S. Hall. From "Proceedings of the American Academy of Arts and Sciences." Pp. 12.

Color-Blindness in Railroad Employés and Pilots. By B. J. Jeffries, M. D. Boston: Rand, Avery & Co. print. Pp. 40.

Medical Jurisprudence. By S. E. Chaillé, M. D. Philadelphia: Reported for "Transactions of the International Medical Congress." Pp. 40.

Filtration of Potable Water. By W. R. Nichols. From the "Massachusetts Health Report." Pp. 90.

Our Revenue System. By A. L. Earle. Pp. 47: France and the United States. Pp. 44; Suffrage in Cities. By S. Sterne. Pp. 41; Protection and Revenue. By W. G. Sumner. Pp. 38. New York: Free-Trade Club, 25 cts. each.

Report on the Retreat for the Insane. Hartford, Conn.: Case, Lockwood & Brainard Co. print. Pp. 27.

Report of the Zoölogical Society of Philadelphia. Philadelphia: The Society. Pp. 28.

The Medical Expert. By W. J. Conklin, M. D. From the *Ohio Medical and Surgical Journal*. Pp. 20.

New Method of planning Researches, etc. By R. H. Thurston. Salem: Printed at the Salem *Press*. Pp. 7.

The Psycho-Physiological Sciences and their Assailants. Boston: Colby & Rich. Pp. 216.

Contributions to Paleontology. By S. A. Miller and C. B. Dyer. With 2 Plates. From the *Journal of the Cincinnati Society of Natural History*. Pp. 16.

Petrography of Quincy and Rockport. By M. E. Wadsworth. From the Proceedings of the Boston Society of Natural History. Pp. 8.

POPULAR MISCELLANY.

Fossil Mammal from the Jurassic of the Rocky Mountains.—One of the most interesting discoveries made in the Rocky Mountain region is the right lower jaw of a small mammal recently received at the Yale College Museum, and described by Prof. Marsh under the name *Dryolestes priscus*. The specimen was found in the Atlantosaurus beds of the upper Jurassic, and the associated fossils are mainly Dinosaurs. The specimen is in fair preservation, although most of the teeth have been broken off in removing it from the rock. The penultimate molar, however, remains in place. The

shape of the jaw and the position and character of the teeth show that the animal was a small marsupial, allied to the existing opossums (*Didelphidæ*). The tooth preserved has the same general form as the corresponding molar of *Chironectes variegatus* (Illiger). The angle of the jaw is imperfect, but there are indications that it was inflected. The present specimen indicates an animal about as large as a weasel. It is of special interest, as hitherto no Jurassic mammals have been found in this country.

Threatened Outbreak of Vesuvius.—Mount Vesuvius is giving signs of an approaching season of great volcanic activity. A bulletin issued by Prof. Palmieri states that the new mouth, which opened at the bottom of the crater in 1872, and which has been more or less active since December 18, 1873, began on May 2d last to give indications of being still more active. The fire cannot be seen from Naples, as it is at the bottom of the crater, and only its reflection is visible on the smoke which rises from it. This reflection is of course greater when the bellows of Vulcan blow up a stronger flame. The smoke, which abounds in acids, mingled with rain-water, is extremely injurious to vegetation, particularly in the direction of Ottaiano, where the vintage has been destroyed for nearly two years. So long as the eruption continues to be central, a long time must elapse before the lava will roll down the sides of the cone, as the cavity of the crater is far from being full. But, should the cone be opened laterally by some extraordinary eruptive force, then the lava will pour out in a deluge.

The Organ-Piano.—Many are the devices that have from time to time been contrived for the purpose of giving to the notes of the piano the "sustained" character possessed by those of the organ. For whatever reason, none of these contrivances have hitherto met with general acceptance, and "organ-pianos" are as yet merely curiosities. But an instrument of this kind is now on exhibition in Paris, which appears to be of practical value, and for which there is already a good demand. There is a brief description of this "organ-piano" in *Nature*, from which we take the following particulars: In this instrument the "organ" or prolonged sounds are produced by a succession of extremely rapid hammer-blows. Besides the usual piano-hammers, the piano-organ has a series of additional hammers (one to each string), mounted on watch-spring levers, all of which are carried by a bar of brass lying across, but above and clear of, the strings. To this bar is attached a rocking lever which is set in very rapid motion by means of an apparatus worked easily by a pedal. The pianist works the pedal, and thus sets the transverse bar with its series of hammers into excessively rapid vibration. By holding down any key of the instrument, the string belonging to it is brought within range of its corresponding hammer, and is struck with corresponding rapidity, giving out what sounds at a short distance like one prolonged note, lasting as long as the pedal is worked and the key is kept down. In this way the performer can produce either piano or organ notes at will.

Sun-Worship among the Moquis.—Traces of sun-worship still exist among the inhabitants of the Moqui villages in Arizona. They have lost the substance of the antique religion, but they retain a portion of the ceremonial—the watching for the emergence of the day-god in the eastern horizon. But it is not the sun they now watch for, but Motecuhzuma (Montezuma), their Messiah, so to speak. Mr. Edwin A. Barber, in the *American Naturalist*, describes as follows the impressive scene witnessed every morning at dawn in the Moqui villages: "As the faint streak of red lights up the low horizon, tall, dark figures appear on the parapets of the seven Moqui towns" (a description of which was given in Vol. VI. of the MONTHLY), "and remain facing the dawn until the sun has appeared entirely to view. Then the muffled forms drop away slowly and sadly, one by one, for another morn has brought disappointment to the souls of many that have watched so eagerly and persistently for the coming of the great Montezuma. The routine of another Moqui day has commenced; all is bustle and life, and the subdued hum of household occupation floats out drowsily on the sullen, sultry air, and the sound of the hundred flour-mills (*metates*), grinding steadily on every

side, seems, as it issues from the doors and windows of the stone houses, to pause in mid-air like a droning bee. Then scores of busy figures repair with their water-vessels to the verge of the steep bluffs, and disappear in the crevices of the rocks below."

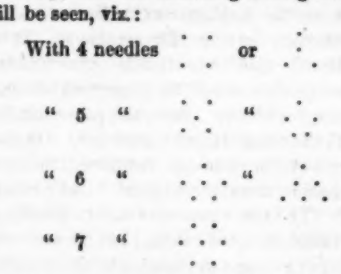
How Monkeys dislike Snakes. — That monkeys, like man, have a peculiar instinctive abhorrence of snakes, is shown by an experiment made in the Philadelphia Zoölogical Garden by Mr. Arthur E. Brown, and recorded in the *American Naturalist*. Mr. Brown having wrapped a dead snake in paper, set the package on the floor of a cage containing forty or fifty monkeys. It was instantly spied by a female cynocephalus, who quickly seized the paper and dragged it away with her. Soon the paper unfolded and the snake slipped partly out. On seeing what the package contained, the cynocephalus instantly dropped it and sheered off. The other monkeys now cautiously approached the dead snake, but all were careful not to come too near, with the exception of one, a large macaque, who would make an occasional snatch at the paper, as though to see whether the dreaded animal were really dead. A pull on a string attached to the tail of the snake, causing it to stir, sent the inquisitive monkeys scampering away, but they would again return, ever keeping at a respectful distance. The dead snake was then successively introduced into cages occupied by animals of other orders — carnivores, rodents, ungulates, etc.—but none of them paid it any special attention except one peccary, which, finding that it was dead, seemed disposed to eat it. The author observed in a deaf and dumb lady the expression of the same emotions and feelings, on beholding serpents, which had been exhibited by the monkeys. There were the same fear, the same attraction and repulsion; and after watching for a long time, with an expression of intense disgust, a cage of boas, she was led away by her friends, protesting that she wanted to stay.

Discoloration of Brick Walls. — Brick buildings, in the neighborhood of New York, are often seen disfigured by streaks and patches of white; but it is in Philadelphia that the evil is most noticeable. There these white incrustations are very general on brick house-fronts, and the study of their causes and their remedy has for some time engaged the attention of builders. Mr. William Trautwine is, so far as we know, the first who has attempted a thorough, scientific investigation of the subject; and his observations, published in the *Journal of the Franklin Institute*, are eminently worthy of the attention of architects in localities where this disfiguration makes its appearance. The evil, he says, is most noticeable in dry weather on parts of walls subjected to dampness, and on entire walls after rain-storms have soaked them. The white coating is derived primarily from both the bricks and the mortar. In some instances it undoubtedly comes from the bricks; here the white substance is dissolved by moisture from the bricks even before they are built into the houses. The author has found it in bricks just from the kiln. It has a peculiar taste—that of sulphate of magnesia; but besides this salt the bricks also contain sulphate of lime. The author's theory is that the silicates of magnesia and lime in the bricks are converted into the sulphates by the sulphuric acid evolved from the sulphide of iron and iron pyrites contained in the coal which is employed in the kilns. Now, sulphate of magnesia effloresces in dry air, and sulphate of lime is dissolved by moisture and appears on the surface of the bricks. Hence, plainly, one mode of preventing the incrustation is the employment only of wood or of coke free from sulphur in the kilns—at least this might be done in the manufacture of pressed brick for house-fronts. As for the incrustations having their origin in the mortar, the author remarks that sulphate of magnesia is largely produced by the decomposition of mortar. His observations on this head have special application to Philadelphia and its vicinity, where most of the lime used in building is from magnesian limestone. The resulting mixture of limestone and magnesia, when slaked and made into mortar, is very susceptible to the influence of sulphurous fumes in the atmosphere, which produce in the mortar sulphates of lime and magnesia. The great solubility of sulphate of magnesia facilitates its diffusion; sulphate of lime is comparatively insoluble, and does not cause so much disfigurement. Of course, mortar made with lime from magnesian limestone quickly decomposes,

and the bricks it was intended to cement become loose. The remedy for this evil is the employment of lime from non-magnesian limestone.

This explanation of the phenomenon of incrustation is pronounced to be the correct one by the editor of the *Polytechnic Review*, who also approves Mr. Trautwine's proposed remedy for the evil. At the same time he offers, on theoretical grounds, a simpler remedy, which he proposes to have subjected to the test of practical experiment. This remedy is the addition of a small quantity of baryta to the water used for tempering the brick-clay. The *rationale* of this process we will state as briefly as possible, mainly in the author's own words: The incrustation being due to the process of soluble sulphates, caused by the decomposing action of sulphuric acid on the magnesia and lime silicate in the clay, the presence of a small amount of free baryta would either altogether prevent or at least greatly reduce the amount of this decomposition. The baryta, having a strong affinity for the free acid, would seize upon it, and with it form insoluble sulphate of baryta. Even though the free baryta did not altogether prevent the formation of the soluble sulphates, it is safe to assume that there will be present in the finished brick sufficient uncombined baryta to decompose and cement into insoluble barium sulphate such soluble magnesia and lime sulphates as may have been formed during the process of burning, so soon as these sulphates are dissolved by moisture. A like addition of baryta to mortar after it is prepared for use may reasonably be expected to check the tendency to efflorescence, except of course where the mortar, as in chimneys, is continuously exposed to the action of sulphurous vapors.

An Interesting Experiment.—A simple experiment, devised by Prof. A. M. Mayer, illustrates in a very effective way the action of the forces of attraction and repulsion on bodies freely moving in a plane, and serves to give clearness to our conceptions of molecular action. He takes a number of needles, of the size known as "number 6," and magnetizes them, giving to all the points the same polarity, say north. Then each needle is driven into a small cork float, so that it will keep the upright position in water, the eye just coming through the top of the float. If, now, three of the needles be dropped into a bowl of water, and the north-pole of a rather large cylindrical magnet be brought slowly down over them, the mutually repellant needles are made to approach one another, and then arrange themselves thus .·. Raise the magnet, and the needles go farther apart; lower it, and they come together again, the three needles always holding their places at the vertices of an equilateral triangle. Add needles successively, and the following arrangements will be seen, viz.:



The needles *can be made* to assume the arrangements shown in the second column, but these figures are not stable. So long as the magnet is held directly over them, the needles will remain in the positions indicated; but raise it, so as to let the needles go apart, and then bring it down again quickly, and in all probability the figure given in the first column will be the result. Prof. Mayer has obtained the figures up to the combination of twenty needles. He adds, in a note to the *American Journal of Science:* "These experiments can be varied without end. It is certainly interesting to see the mutual effect of two or more vibrating systems, each ruled more or less by the motions of its own superposed magnet; to witness the deformations and decompositions of one molecular arrangement by the vibrations of a neighboring group; to note the changes in form which take place when a larger magnet enters the combination, and to see the deformation of groups produced by the side action of a magnet placed near the bowl."

Experiments with the Electric Light.—A public exhibition was recently made in Cleveland, Ohio, of an electric-light machine

invented by Mr. Charles E. Brush, of that city. The results were in the highest degree satisfactory, as will be seen from the following account of the experiment which we condense from the *Cleveland Herald*:

The machine is capable of giving a light of 12,000 candle-power, the electric fluid being distributed to four electric lamps, each having the power of three thousand candles. The exhibition was given in the establishment of the Union Steel Screw Company, where two of the lamps were placed on the third and two on the fourth floor of the immense building. The illumination was perfect. The rooms were flooded with a pure white light like the light of the sun, and it streamed out at all the windows, illuminating houses and streets for a long distance in every direction. The light was very uniform and steady, free from the flickering that used to be an accompaniment of electric light, and, considering the enormous illuminating power, the light was unexpectedly soft and endurable to the eyes. An opportunity was afforded to test the character and whiteness of the light. Worsteds, scarfs, afghans, etc., of brilliant shades were hanging against the wall at one side of the room, and it was noticed that the colors were brought out as clearly as by the full light of the sun. Estimates were made as to the amount that the light furnished by this apparatus would cost, if used by the Screw Company as it was used on the evening of the exhibition, and it was ascertained that the total cost of the whole light from the four lamps, including the items of consumption of carbon in the lamps, interest on the investment, and wear and tear, would not exceed thirty cents per hour. The light produced was photometrically equal to eight hundred gas-burners, burning five feet of gas per hour each. This amount of gas would cost eight dollars per hour in Cleveland.

Ascent of Mount Ararat.—In September, 1876, Mr. J. Bryce made the ascent of the greater peak of Mount Ararat, and at a recent meeting of the London Geographical Society gave an account of the feat. Mount Ararat is situated nearly in the centre of the region known as Armenia—a territory divided between three empires, and lying round the sources and upper courses of the Araxes, Euphrates, and Tigris. The mass of Ararat is about twenty-five miles long from northwest to southeast, and from twelve to fourteen miles wide. It consists of two peaks joined together by a sort of neck. The greater peak, Great Ararat, rises 17,000 feet above sea-level, and the lesser peak, Little Ararat, 12,800 feet; both are of volcanic origin. Mr. Bryce began the ascent from a small Tartar village on the northeastern face of Great Ararat, being accompanied by a friend and two guides, a Cossack and a Kurd. At the height of about 11,500 feet Mr. Bryce's friend abandoned the attempt to reach the summit. The remainder of the climb had to be made over beds of snow, and over bare, loose, broken stones; the latter course Mr. Bryce chose. At the height of 15,000 feet the Cossack and the Kurd refused to go any farther, so he was compelled to journey alone. The last part of the ascent was upon a slope of rotten rocks, rather soft and sulphurous, which crumbled under his feet, adding greatly to his fatigue. Near the top of this slope Mr. Bryce could just discern the edges of the plateau of snow, and hanging on this a curtain of clouds. After ascending into these clouds two strong blasts of wind swept them away, and then a wonderfully grand and extensive view lay before him. The Caucasus could be seen to the north, distant about 250 miles; the highest ranges of mountains round Erzeroum to the west; the mountains of Assyria, and South Kurdistan, the mountains in the direction of Nineveh, and the valley in the direction of the Zab, to the south; to the east, the enormous mountain-masses in Persia, and north as far as the Caspian. But in his fondest anticipation Mr. Bryce was doomed to a sad disappointment: he could find no fragment of Noah's ark!

Prevention of Contagious Diseases.—Two modes of fortifying the system against the attacks of zymotic disease are pointed out by Dr. E. M. Hunt, in the *Medical Record*, viz.: topical application of substances inimical to the development of contagia; and, secondly, the introduction into the blood of substances which shall prevent fermentive, defibrinizing or destructive processes. On the hypothesis that *contagium vivum* is introduced into the

human system from without, and mostly through the inbreathed air, the author advocates the charging the mouth and nostrils with antiseptic substances so as to render the breath and the tissues more immediately exposed unfriendly to the development of the contagium. When the floating infective particle presents itself either for local manifestation or for absorption, it may require "but slight unfriendliness of reception to prevent morbid result." In diseases like diphtheria and scarlet fever, which at the outset have such marked local manifestation as to lead us to believe that they are local before they are constitutional, topical application of remedies seems to be clearly indicated. But the author thinks that the introduction of certain substances into the blood is a still more effectual mode of combating contagia. In this way not only are the portals of entrance protected, but the fluids, glands, etc., of the system are so permeated with the antiseptic or antifermentative agent as to be able to withstand the action of the disease-germ. How much may be due to the local hinderance to fertilization, and how much to the constitutional resistance established, may not in each case be easy to determine. But when we consider how readily chlorate of potassium, after being administered, is found in the secretions, how soon a few grains of pure protochloride of iron increase the number of the red globules of the blood, how defibrination of the blood is retarded by certain agents, we are justified in the hope that our power to suspend the action of disease-poisons will yet be greatly augmented.

Creosote as a Timber-Preserver.—Railway-ties, dried, and saturated with creosote, will last, according to Mr. E. R. Andrews, for twenty years or more in good condition. In ties so treated the spikes intended to hold the rail do not corrode nor work loose. Then, too, the surface of the tie under the rail does not decay nor wear, because it is not affected by alternate dryness and moisture. In the construction of wharves and in ship-building, creosoted timber is also of great advantage. It is proof against the ravages of the *Teredo navalis* and other mollusks which cause such destruction of timbers submerged in sea-water. The woods best adapted for the creosoting process are those which are light and porous, as these most readily absorb the creosote; so treated they become more solid and enduring than the most costly species of timber. "The cottonwood of the Southwest," writes Mr. Andrews, in the *American Gaslight Journal*, "can be made as useful as oak for ties. White pine absorbs creosote like a sponge, and the yellow pine of the South takes it readily also. In England fir from the Baltic is used altogether for ties, and I do not see why the despised fir from our forests may not be used for the same purpose here. Hemlock is good also; spruce is a firm, compact wood, and absorbs oil with more difficulty; neither does it require so much to preserve it. Oak has a coarse fibre, and is easily treated."

The Eyes of Deep-Sea Animals.—In giving to the National Academy of Sciences an account of recent dredging and sounding in the Gulf of Mexico, Prof. Alexander Agassiz referred to the question of sight in marine animals living at great depths. He said that the crustaceans and fishes taken from depths of from 1,500 to 1,900 fathoms or more present conditions diametrically opposite to one another with respect to vision, some of these creatures being eyeless or nearly so, others having eyes enormously developed, as if to enable them to see with the faintest glimmer of light. In the former class many very curious modifications of structure are to be seen taking the place of the eyes. The existence of these very wide differences of structure under identical conditions he regarded as strange, but, in the discussion which followed the reading of the paper, Profs. Cope and Gill held that this difference was precisely what we might expect, according to the evolution hypothesis. There is nothing surprising in the fact that in one set of animals "survival of the fittest" should work obliteration, and in another class abnormal development of the visual organs.

Studies of Embryo Life.—On opening the shell of a hen's-egg in the third day of incubation, Harvey noticed the heart-beats of the embryo, which, however, soon ceased. He then placed the egg in warm water, and the heart commenced to beat again. The same experiment, but with im-

portant modification, has been repeated by M. Dareste, who for some years past has devoted himself with great assiduity to the study of embryo life. He took from under a hen an egg on which she had sat for three days, and let it remain in the ordinary temperature for two or three days. He then again placed it under conditions favorable to incubation, and in due time a chick was hatched out, just as if there had occurred nothing unusual in the mean time. The result of this ingenious experiment, as M. Stanislas Meunier observes in *La Nature*, is to show that life may be suspended for a considerable length of time in warm-blooded animals without fatal effects, precisely as in animals of a very low grade, such as *Rotifera*.

Mars's Fast Moon.—The periodic time of the inner satellite of Mars is only very little over seven hours, while the axial rotation of Mars itself requires about twenty-four hours. Now, this discrepancy is in apparent conflict with the nebular hypothesis, which assumes all the secondary bodies of a system to have been evolved from their primary at successive stages, with the velocity of the primary's surface at the time of their being dropped as rings of nebulous matter. But here is a planet's satellite possessed of a velocity of revolution more than thrice as high as the velocity of axial rotation possessed by its primary. The problem, how to account for this accelerated movement of the inner Martial moon, has occupied the attention of astronomers since the discovery of Mars's satellites by Prof. Asaph Hall, a few months ago. The theory proposed by Prof. M. H. Doolittle, of the Coast Survey, appears to solve all the difficulties of the case. In three ways, according to Prof. Doolittle, the relative velocities of Mars and his moon might be modified by the impact of interstellar matter, or meteorites: 1. These bodies, by striking the satellite and forcing it to travel in a narrower orbit, its original absolute velocity continuing the same, would increase its relative velocity; 2. By striking the primary, they would increase its mass and its attraction on the satellite; 3. By increasing the mass of the primary and so reducing its absolute velocity they would make the relative velocity of the satellite higher.

NOTES.

THE American Association for the Advancement of Science will assemble in St. Louis, on August 21st. The officers are: President, Prof. O. C. Marsh; Vice-President of the Physical Section, Prof. R. H. Thurston; Vice-President of the Natural History Section, Prof. Augustus R. Grote; General Secretary, Prof. H. Carrington Bolton; Secretary of Section A, Prof. Francis E. Nipher; Secretary of Section B, George Little; Treasurer, William S. Vaux; Chairman of Chemical Sub-section, Prof. F. W. Clarke.

THE British Association meets this year in Dublin, on August 14th, under the presidency of Mr. William Spottiswoode, F. R. S.

DURING the summer vacation, teachers of mathematics or astronomy will be admitted to the Cincinnati Observatory, there to pursue the different branches of study connected with their special departments of instruction. Applications should be made to the director of the observatory, Mr. Ormond Stone.

THE French Association for the Advancement of Science will this year hold its meeting at Paris, commencing August 22d. The officers of the Association are: President, Prof. Frémy, of the Academy of Sciences; Vice-President, M. Bardoux, Minister of Public Instruction; Secretary, M. Perrier, commandant d'etat-major.

THE death of Dr. Charles Pickering, of Boston, is announced. He was a grandson of Timothy Pickering, and was born in Susquehanna County, Pennsylvania, on November 10, 1805; graduated at Harvard College in 1823, and three years later received his medical diploma. He was a member of the scientific staff on board of the United States ship Vincennes during Commodore Wilkes's Exploring Expedition around the world from 1838 to 1842. In 1843 he went to India and Eastern Africa, to complete his ethnological researches, and on his return home two years later began the preparation of his great work, "The Races of Man and their Geographical Distribution" (1848). He later published "Geographical Distribution of Animals and Man" (1854), and "Geographical Distribution of Plants" (1861).

IN the Azores, a Portuguese subscribes himself at the foot of a letter as "your watchful venerator"—an expression doubtless as sincere as "your obedient servant." He dates all letters written from his own house "S. C.," meaning *sua casa* (*your* house), and he addresses them "S. I. C.," i. e. *Sua ilustre casa* (to your illustrious house). By a fiction of politeness, he assumes that the house he lives in is one of

the inferior mansions of the person he happens to be writing to, who, possessing a more illustrious habitation, allows the writer to occupy it by indulgence or sufferance.

DURING the discussion of hell-fire which lately swept over this country, we did not notice in any of the brethren such gracious evidence of a meek and loving spirit as in "Brother" Swigart, of Huntington, Pennsylvania; Brother Swigart is what is known as a "Pilgrim Baptist." Says the *Primitive Christian:* "At our last prayer-meeting Brother Swigart took the position that we have nothing to do with hell. It was not prepared for the Christian, and *therefore need not concern us.* Heaven is the place about which we are concerned, and not hell."

THE educational authorities of Berlin maintain a vast garden for the purpose of supplying fresh botanical specimens for the public schools of the city. Over 4,000,000 plants are required for botanical instruction during the year.

THE biological department of the Johns Hopkins University will this summer organize at Fort Wool, Virginia, a laboratory for the study of marine zoölogy, the sessions commencing June 15th, and continuing till August 15th. The laboratory is designed to meet the wants of advanced scientific investigators, but at the same time there will be accommodations for a few less advanced students. A fee of ten dollars will be charged for the use of laboratory and apparatus, and board will be furnished at cost. Address Dr. W. K. Brooks, Johns Hopkins University, Baltimore.

A SHORT time ago we published a few specimens of the absurd anomalies of our common "systems" of weight and measure. Many others are cited in a late number of the *Polytechnic Review.* Among these we notice two as being specially absurd. Thus a law of the colony of Pennsylvania, about the year 1705, enjoined that all brewers "shall sell beer and ale by wine-measure to all persons as *drink it in their houses,* and by beer-measure to all such persons as *carry* the same out of their houses." The other instance is quoted from Mr. Charles Reade, who says that in Shropshire they at one time actually had different weights for different market-days!

EXACT experiments made by Grehant show that a man, or one of the lower animals, compelled to breathe for half an hour an atmosphere containing only $\frac{1}{1\,1\,5}$ of carbonic acid, absorbs that gas in such quantity that about one-half of the red blood-corpuscles combine with it and become incapable of absorbing oxygen; and that, in an atmosphere containing $\frac{1}{2\,2\,5}$ of carbonic oxide, about one-fourth of the red corpuscles combine with the gas.

DR. PERCY, F. R. S., at a recent meeting of the British Iron and Steel Institute, gave some particulars as to the manufacture of Japanese copper. Bars of this metal present a beautiful rose-colored tint on their surface, which is due to an extremely thin and enduring film of red oxide of copper, and which is not in the least degree affected by free exposure to the atmosphere. Dr. Percy exhibited bars of Japanese copper which had been in his possession thirty years, and which had undergone no change, though freely exposed to the action of the air. The secret of this result is that the copper is cast under water, the metal being very highly heated, and the water, too, made hot. Dr. Percy had himself succeeded in casting copper in this way, with results the same as seen in the Japanese metal.

WHITEBAIT, a favorite fish among British epicures, has made its appearance in the bay of New York. Mr. Eugene Blackford, of Fulton Market, is satisfied of the identity of the fish caught here with the English whitebait. Only a few specimens have been found as yet, but a full supply is anticipated when the proper nets are procured, and shoals of the fish are discovered.

THE sum voted by the French Chambers for the maintenance of the national museums during the present year is 762,780 francs. With this pittance have to be defrayed all the expenses of the great museums of the Louvre, the Luxembourg, of Versailles, and St.-Germain-en-Laye, with their branches. Attention is called in *La Nature* to the significant fact that the single *Théâtre de l' Opéra* receives from the state a larger bounty than all these great museums taken together. In consequence of this parsimony on the part of the Government, many of the great French collections, once justly esteemed to be the completest of their kind in the world, are now far surpassed by similar collections in other countries.

THE state of the "temperance question" in the United Kingdom of Great Britain and Ireland may be inferred from the following statistics, derived from official sources: In 1877 duty was paid in the United Kingdom on 29,888,176 gallons of home-made spirits, intended for home-use. This is 62,112 gallons less than in 1876, but the decrease is due exclusively to Ireland. England shows an increase of 414,947 gallons, and Scotland an increase of 16,051, but Ireland shows a decrease of 493,110 gallons. The number of gallons destined for consumption in England was 16,853,082, in Scotland 6,987,189, and in Ireland 6,047,905. The 10,618,564 proof gallons of imported foreign spirits entered for consumption in the United Kingdom in 1877 were less by 883,176 gallons than the quantity in the preceding year.

THOMAS A. EDISON.